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ECONOMIC CONSIDERATIONS IN CROP INSURANCE

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ABSTRACT

This report traces the evolution of crop-hail and all-risk crop insurance. It describes the present use of each kind of insurance among crops, States, and regions in terms of coverage, premiums paid, and indemnities. It compares and contrasts the kinds of insurance and their inherent differences. The different natural hazards to growing crops are listed and concepts of crop yield variability, the sources of variability, and the impact of production technology are discussed. Analyses are made of the relation of coverage to indemnities and premiums on individual farm contracts, and how they differ under conditions of high or moderate yield variability. The report discusses the problem of adverse insurance risks, and illustrates the use of normal distribution theory and statistical procedures in projecting probable indemnities in all-risk crop insurance. It analyzes the influence of the level of yield guarantee and the "shape" of the yield distribution on probable indemnities. The question of the financial reserves that may be needed by the insurer is examined.

Key Words: Crop insurance, crop-hail insurance, crop losses, yield variability, premium reserves.

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SUMMARY

A nationwide sample survey and several smaller studies indicate that both commercial crop-hail insurance and Federal crop insurance (FCI) are used by all size and tenure groups of farm operators as well as by crop-share landlords. Some of the important differences between commercial crop-hail insurance and Federal all-risk crop insurance are:

1. Crop-hail protects only against hail and wind damage, whereas FCI protects against crop loss from nearly all natural causes.

2. Crop-hail can be bought for any dollar coverage up to the full value of the expected crop. FCI coverage is limited to production expenses in the form of one yield guarantee, with one to three price options. This causes the extent of coverage to vary among crops as the direct production expenses vary from about 30 percent of the gross return for dryland wheat to about 50 percent for corn and 60 percent for soybeans, cotton, and tobacco.

3. Crop-hail can be purchased at any time up to harvest, whereas Federal all-risk crop insurance must be purchased no later than planting time.

4. Premium rates on crop-hail are set not only to cover indemnities, but also to build reserves, pay operating costs, and return a profit. FCI premium rates are designed to cover only indemnities as program-operating expenses by law are borne by the Government.

5. Crop-hail indemnities are based upon the percentage of loss and the insurance coverage, by acre, whereas FCI indemnities are based upon the amount by which the average yield of the crop for the entire farm falls below the guaranteed yield.

In analyzing the economics of all-risk insurance, a useful concept is that of a maximum potential crop yield for a specified soil-climate environment and technology. Actual yields fall below the potential yield in various degrees because of losses due to natural hazards. Thus, average yields are the potential yield minus some average loss due to natural hazards. Insuring the full potential yield against every conceivable natural hazard would require a very large premium. It is therefore more practicable to insure the average yield, which means that the crop is protected against somewhat less than the full impact of all natural hazards.

The potential yield itself may vary depending upon the technology used by different growers. Some growers apply production inputs intensively to achieve maximum net revenue on a limited acreage, whereas others spread the same production inputs over a wider acreage to maximize the net return per dollar of

input. The two would have not only different yield potentials but different insurance coverage needs.

All-risk crop insurance differs basically from crop-hail in regard to the relation between insurance coverage, premium rates, and indemnities of the individual farm contract. In crop-hail insurance, the indemnities are computed as the percentage of the crop damaged multiplied by the level of coverage. But, with all-risk crop insurance, the indemnities cannot be based on a percentage of loss because losses can result from different causes through the season. Therefore, indemnities are based on a yield guarantee.

If the potential yield of the crop increases over time because of improved technology, then the yield guarantee may become conservatively low, even obsolete. To compensate, the yield guarantee can be updated in correspondence with a time-series trend line.

A problem in administering all-risk (multiperil) insurance is that of distinquishing between those crop losses due to poor farm management and those due to natural causes. The problem arises because of the yield guarantee. A feasible solution to the so-called adverse risk problem may be to adjust the yield guarantee in the contract downward to the expected lower yield level of the farm as indicated by the quality of practices and quantity of fertilizer and other inputs used. The same result is not achieved, however, if the premium rate rather than the yield guarantee is adjusted. Premium rate adjustment does not affect the likelihood of an adverse risk farmer having a loss claim. Similarly, the yield guarantee should be adjusted upward for the superior farmer. A program could have three levels of yield guarantee corresponding with three levels of management.

Insuring companies need to project their probable indemnities for purposes of premium ratemaking and program budgeting. Until loss experience is deemed adequate, use can be made of normal distribution theory along with "areas under the normal curve." The pattern of farm yield distributions can be determined from sample yield data or it can be simulated.

Study of the 20 years during 1948-67 shows that the variability of all-risk loss ratios were roughly twice as large as crop-hail loss ratios. That suggests that insuring companies may need to establish capital reserves from which to pay indemnities in an unusual crop-loss year. Capital reserves could be established by selling stock or by charging slightly higher premiums. For large programs a premium charge 10 percent larger than needed to cover indemnities would in 10 years accumulate a premium reserve equivalent to 1 year's premiums.

ECONOMIC CONSIDERATIONS IN CROP INSURANCE

by

Warren R. Bailey and Lawrence A. Jones

INTRODUCTION

Most business undertakings, including farming, involve economic risks of one sort or another. At least some risk-taking is considered normal and is used to explain profits. However, in some kinds of businesses, notably crop farming, the economic risks can be substantial. They are chiefly of two kinds--production risks and product price risks.

Price risk occurs because crop prices are not set by the farmer but are set by supply and demand in the commodity markets--except for price-supported crops. Hence, the product price at harvesttime may not equal the price the crop farmer expected months earlier when he committed his expenses in producing the crop. Government price supports are designed to put a seasonal floor under the prices received by farmers for certain crops. Such programs also provide a measure of "free" crop insurance in that wheat certificate payments and price-support payments for feed grains and cotton are computed on "normal" yields, not on the actual yields of the current year.[1] It is doubtful whether this "involuntary insurance" feature is the sole reason for participation in commodity programs by more than a few farmers. Yet, because of it, some may feel less need to employ other risk-bearing strategies such as crop insurance.

The crop production risk is that of a reduced yield or a crop failure relating to natural hazards of two kinds: (1) adverse weather--hail, wind, frost, drought, excessive moisture or flooding, and "late spring," and (2) pests--insects, plant diseases, and weeds.[2] Production risks due to adverse weather are greater in some crops and regions than in others. Drought is frequent in the Great Plains; frost in northern areas; hail in the Upper Midwest.

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[1] Direct payments to growers under the feed grain, wheat, and cotton programs totaled over $2.5 billion in 1967. For example, cotton growers received price-support payments of over $611 million and acreage diversion payments of more than $320 million, neither of which were contingent upon the cotton yield which was very poor in some areas. Indemnities paid by the Federal Crop Insurance Corporation for cotton losses totaled about $13.5 million in 1967.

[2] "Late spring" refers to cool weather and other conditions that interfere with germination and emergence of seedling plants.

As a result of production and price risks, the annual returns and incomes of a crop farmer can vary widely from year to year. To cope with such variations, crop farmers may adopt a variety of business strategies besides crop insurance, a fact that should be kept in mind as this report is read.

One strategy is to create and maintain financial or credit reserves, a strategy that may be more feasible for the older or better established grower, but more difficult for the beginning or low-income farmer. Maintaining financial reserves admittedly can be a relatively uneconomic way of dealing with production risks for those operators who urgently need more capital in their farm business.

In addition to debt-payment rescheduling, farmers may concentrate their major farm machinery and family purchases and household improvements in good crop years, and curtail such expenditures in the poor years, with less serious consequences to farm operations and family living.

Accumulating grain reserves from good crops that can be sold or fed to livestock in years of low crop yields is a common practice in the Great Plains and other grain-producing areas. The establishment of grain reserves has been encouraged by a feature of the Federal production adjustment programs that permitted farmers to overplant their acreage allotments provided they stored and did not market in the current year the production from the excess acreage.3/

FHA emergency loans, when available, can aid recovery from the impact of a poor crop. To be eligible, the farm operation must either be in a designated natural disaster county or the farmer be able to prove that he has suffered a disaster and is unable to get regular credit. FHA loans are not ordinarily available to crop-share landlords.

The present report does not deal in detail with the aforementioned strategies for reducing the impact of crop losses on growers, but instead concentrates on the economics of the two principal kinds of crop insurance--crop-hail and all-risk. Crop-hail insurance is sold chiefly by private insurance companies, though the Montana State Hail Insurance Department also offers it. Crop-hail insurance coverage can be purchased for the full reasonable value of the expected crop, at commensurate premium rates. Indemnities are proportional to the percentage of crop hail damaged. Some contracts do not pay indemnitites for damage under 5 percent.

3/ The wheat program permits growers to plant up to 150 percent of their allotted acres and store the excess production for sale during years of low production. In 1966, more than 5,900 farms exceeded their allotments by 453,129 acres. This was only about 1 percent of total wheat acreage planted but was important in eastern Colorado and Wyoming, and in western Nebraska. Farmers using the option in those States overplanted their allotments by an average of about 40 percent. In 1967, fewer acres were overplanted because of different production conditions.

All-risk insurance is sold mainly by the Federal Crop Insurance Corporation, although commercial multiperil crop insurance has been available in five States since 1969. Federal all-risk crop insurance coverage is based on a yield guarantee, at commensurate premium rates. Coverage is limited by law to crop production expenses, not to exceed 75 percent of the normal crop value. Indemnities are based on the difference between the actual crop yield and the yield guarantee. Some growers supplement their FCI with enough crop-hail insurance to provide full coverage.

Part I of this report briefly discusses the nature of crop production hazards, the beginnings and evolution of crop insurance, the extent of present participation, and the characteristics of current crop insurance contracts--both crop-hail and the all-risk type.

Part II, being more analytical, examines crop yields and their variability, basic concepts, the sources of variability, the impact of production technology, and the relevance of these matters to crop insurance. We also analyze and discuss the relationship of the level of insurance coverage to the probability of indemnities and the necessary premium rates, with reference to all-risk crop insurance, under conditions of both moderate and high year-to-year variability. We discuss the matter of adverse insurance risks. We examine the insurer's problem of projecting the probable indemnity claims in all-risk crop insurance--the effect of variability and the level of yield insured, separately and in combination. Finally, we discuss the capital reserves needed by a crop-insuring company, as indicated by some historical evidence of indemnities paid.

PART I. GENERAL CONSIDERATIONS

Crop insurance is widely used by farmers to protect themselves from the financial impact of the loss of a growing crop due to natural hazards--weather, disease or weeds. Commercial crop-hail insurance became significant in the 1920's. Crop-hail insurance coverage of about $3.5 billion is now purchased by about 500,000 farmers. All-risk crop insurance sold chiefly by the Federal Crop Insurance Corporation was initiated in 1939. The program has expanded to its present size of nearly $1 billion coverage, $50 million in annual premium revenue, and 350,000 farmer and landlord users. Federal Crop Insurance is now available for 25 different crops in nearly half the rural counties in the United States. Four-fifths of the insurance coverage is on 5 crops: wheat, tobacco, corn, cotton, and soybeans.

THE NATURE OF CROP PRODUCTION HAZARDS

Hail storms occur across much of the United States, but the chief hail insurance area extends from central Montana to Virginia and North Carolina, reaching south to Kansas, Missouri, Southern Illinois, and Kentucky. Hail may damage a growing crop at any time up to harvest. Tobacco's susceptibility to hail damage is a major factor in the relatively high insurance participation among tobacco growers.

The hazard of drought is greatest in the Great Plains where wheat, barley, and grain sorghum are the main insured crops, and in the western Corn Belt where those crops plus corn and soybeans are insured. Frost is a hazard to wheat and barley in the northern parts of Montana, North Dakota, Minnesota, and Wisconsin, to corn and soybeans throughout the Corn Belt; and to cotton and soybeans in the Cotton Belt. Excess moisture and flooding are hazards to all crops in all areas. Unfavorable early season weather may affect seed germination or seedling emergence and hence the eventual yield, particularly of crops like corn and cotton.

Although as yet man has little control over the weather, the risk of crop losses due to drought has been lessened. We now have varieties of crops that are more resistant to droughts. And through the use of summer fallow, stuble mulch tillage, and more timely operations we are able to conserve more soil moisture for the use of crops. The use of fallow has been greatly encouraged by the crop allotment and acreage diversion programs in the wheat- and barley-producing areas. Nevertheless, drought remains a serious hazard annually in the Great Plains and seasonally (late summer) in the more humid East and South.

Thanks to technology, the likelihood of crop loss due to insects, disease, and weeds has been reduced in recent years. First, technology has provided new varieties that are resistant to disease and insects as, for example, the wheat varieties resistant to race-15 black stem rust. Second, technology has also provided chemical sprays and other protective treatments. Herbicides, along with improved cultivation, effectively control weeds. Thus, the hazards due to insects, disease, and weeds are now, to a greater degree, under the control of the competent farm manager. Nevertheless, unforeseen outbreaks of insects and disease occasionally occur, and wet seasons still can hamper weed control.

EVOLUTION OF CROP INSURANCE

Crop insurance is not a recent phenomenon. More than 80 years ago commercial insurance companies began to offer crop-hail insurance in a limited way. The Federal all-risk crop insurance was initiated more than 30 years ago. Since that time, the FCI has been expanded to 25 crops, extended into half the U.S. counties, and has undergone many changes. Recently, commercial insurance companies have experimented with all-risk (multiperil) crop insurance and are offering it in a few States.

Crop-Hail Insurance

Crop insurance was first used to protect against losses due to hail damage, and is still widely used for that purpose.

In 1880, tobacco growers in Connecticut organized a mutual hail insurance company that continued in business for 7 years. It was promptly followed by the formation of another company in an adjoining county, the success of which is not recorded. In 1883, some fire insurance stock companies first offered hail insurance to crop farmers (3), (9), (12).

These early attempts at offering crop insurance were sporadic and short-lived. Little was known then about the frequency or the severity of hail damage within an area. By 1919, out of some 121 mutual hail insurance companies that had operated at one time or another, 80 had discontinued.

During the 1915-20 period, crop insurance received a new impetus by the organization of several new companies. In addition to 43 stock companies and several mutual companies then in business, the State legislatures of Montana, Nebraska, North Dakota, and South Dakota established State crop-hail systems, Colorado started a State system a bit later. In 1919, the total volume of crop-hail insurance reached $559 million. Of this, the stock companies held almost half, and the remainder was about equally divided between the mutual companies and the State crop-hail systems. During the 1920's, the amount of crop-hail insurance used by farmers declined and by 1934, it totaled only $87 million. Since the mid-1930's, crop-hail insurance has expanded rapidly, mainly via the commercial mutual and the commercial stock companies, as all of the State-sponsored crop-hail insurance systems except Montana's have been discontinued.

Crop-hail insurance is generally available in all areas of the country where hail risk is significant. It is widely used on tobacco in the Appalachian region, on corn and soybeans in the Corn Belt, and on wheat, barley, and grain sorghum in the Great Plains. In 1969, crop-hail insurance with coverage estimated at $3.6 billion was bought by more than 500,000 farm operators and landlords. Total indemnities averaged 63 percent of premium income, which has exceeded $100 million annually since 1962 (table 1).

All-Risk Crop Insurance

Although the commercial insurance companies have become firmly established in the crop-hail insurance business, they have not yet developed a significant program of all-risk or weather-perils insurance, mainly because of large losses incurred because of drought. On the other hand, the Federal Crop Insurance Corporation has offered all-risk insurance every year but one (1944) for about 30 years.

Early Experience

The first recorded attempt (and failure) to offer insurance was that of a company organized in 1899 to sell weather-perils insurance in North Dakota and Minnesota. Almost two decades later in 1917, three companies attempted to offer all-risk insurance in the Dakotas and Montana, but they soon discontinued the operation. Again in 1920, several larger insurance companies attempted to insure grains and cotton, but without success. During the 1920's and 1930's, only a few attempts were made by commercial companies to offer all-risk crop insurance, all of which were discontinued.

In the early 1920's, officials in the U.S. Department of Agriculture became interested in crop insurance and carried on some research. Victor N. Valgren, a pioneer in agricultural insurance, wrote a bulletin in 1922 that developed many of the principles of crop insurance which eventually became the basis for Federal crop insurance (13). In 1923, a U.S. Senate Committee held hearings on crop insurance. At that time, however, it was thought preferable for the Government to assist private insurance companies rather than to go into the business itself. From the mid-1920's to the mid-1930's, there was relatively little discussion of crop insurance.

Federal crop insurance

A resurgence of interest in all-risk crop insurance took place in the mid-1930's, largely because of the extended drought in the Great Plains. In 1936, President Roosevelt appointed a "President's Committee on Crop Insurance" that included Henry A. Wallace, Secretary of Agriculture, H.R. Tolley, Administrator of the Agricultural Adjustment Administration, A.G. Black, Chief of the Bureau of Agricultural Economics, as well as the Assistant Secretaries of the Commerce and Treasury Departments. After meetings with Government officials, the commercial insurance industry, and various farm groups, the President's Committee in 1937 recommended a plan for crop insurance to Congress. Following another year of legislative activity and hearings, an Act of Congress creating the Federal Crop Insurance Corporation was passed in February 1938 (1, 5, 8, 10).

The original Act provided only for insurance on wheat, beginning with the 1939 crop; insurance on cotton began in 1942. Both were very large programs in which the insurance was offered nationwide. Losses exceeded premiums on both wheat and cotton in each of the first 5 years, 1939-43 (table 3). Although heavy losses resulted directly from droughts, winterkill, and other causes, there were also some defects in the insurance plan and administrative operations. Because of the disappointing experience of the early years, Congress passed legislation withdrawing the insurance in the 1944 crop year.

The crop insurance program was revived by Congress in 1945 with insurance on wheat, cotton, and flax to be made generally available. Experimental work also was to be started on corn and tobacco in a few counties. Experience improved with wheat, and was satisfactory with flax, corn, and tobacco. However, large program losses occurred on cotton in both 1945 and 1946, primarily because of widespread drought in the Southwest. In 1946, total indemnities for all crops exceeded premiums by $28 million--a loss ratio of 1.80 (table 3). By the end of that year, more than 75 percent of FCIC's original capital stock of $100 million had been used to pay losses not covered by premiums.

As a result of the heavy losses, Congress passed legislation placing Federal crop insurance on a limited experimental basis in 1948, and directed FCIC to develop a sounder basis for its all-risk insurance. Insurance in 1948 was authorized in only 200 wheat counties, 56 cotton counties, and a smaller number of counties for other crops. Previously, insurance had been available in about 2,500 counties. Congress also indicated that experimental work should be done on other crops. At the same time, Congress restored the original capital stock authorization of $100 million.

Between 1948 and 1969, insurance protection under FCI increased from $154 to $908 million (table 4). The number of crops eligible for insurance expanded to 24, and the number of counties in which insurance was available increased from 324 to 1,425. Legislation limited expansion in any one year since 1948 to 3 new crops and 150 new counties. The period of most rapid growth was from 1962 to 1967.

The loss experience of FCIC was much better for the 1948-67 period than in years prior to 1948. Indemnities paid out during 1948-67 were equal to 96 percent of the premiums paid in by farmers.

Changes in Federal crop insurance

As FCIC gained experience, many changes were made in premium rates, coverages, policy features, and in loss-adjustment methods. The following statement from the October 1963 Federal Crop Insurance Manual gives many of the major changes in the program that have developed over the years:

> From the start of the program until 1948 the farmer had the option of insuring either 75% or 50% of the long-time average yield on his farm. Most of the insurance was written for 75%. Since 1948, the insurance by legislation has also been restricted generally to the investment in the crop for the area. This has resulted in a more conservative level of insurance. When risks are high the level of protection must be adjusted to an amount that can be provided at a practical annual premium level which may mean that only the out-of-pocket costs or the annual cash outlay is protected.
>
> In the early years an insured was paid losses on the basis of one level of protection regardless of when the crop failed or what use was made of the land. With the revival of the insurance in 1945 a progressive coverage was adopted to reflect some of the differences in operating costs at different stages of crop development.
>
> Early insurance contracts were annual contracts requiring new applications for protection each year. Use of continuous contracts that may be cancelled by the insured or the Corporation prior to established dates started in 1948.
>
> The original concept was one of insurance "in kind" to avoid price risks since the legislation provides for insurance against loss of production and not for a guarantee of dollar return. Warehouse receipts for wheat were given for indemnities the first year and even a few premiums were paid in wheat. This grew into a system whereby the farmer paid his premium in cash at current values for the day the premium was paid and the Corporation bought wheat or cotton with the funds. Indemnities paid farmers were in cash at the current value of the wheat or cotton due him and wheat or cotton in the reserves was sold to provide the funds. The buying and selling of wheat and cotton became essentially a hedging operation to protect the Corporation against price changes between the time of establishing the price basis for premiums and establishing the price basis for indemnities. Then, the Corporation changed to the use of a fixed price for each year which was used to establish both premiums and indemnities and eliminated hedging operations.
>
> The fixed price method was replaced by a Guaranteed Production Plan. Under this plan a percent of loss was determined by comparing the commodity guarantee with the actual production. The percent of loss was then applied to a dollar selection per acre made by the farmer to

determine the amount of the dollar indemnity to be paid.. This plan was designed to enable the farmer to fit the protection more closely to what he regarded as most practical for him from a protection and premium standpoint.

The Guaranteed Production Plan has been gradually replaced by a plan which retains the production guarantee but provides for selection by the policyholder of a price per bushel, pound, cwt., etc. Determination is made of the amount below the commodity guarantee which is multiplied by the unit price selection to determine the dollars of indemnity due. Some plans provide a production guarantee with an increase in protection for harvested acreage when the amount harvested equals or exceeds the increase provided for harvesting. Others have a production guarantee with a minimum appraisal for unharvested acreage.

Specialty Crop Insurance plans are adapted to the crop and the risks being insured, and most of them necessarily vary somewhat from the general plan applicable to most of the so-called basic crops.

The original policy of permitting farmers to purchase insurance until planting time regardless of crop conditions has been changed. Earlier closing dates have been set for years when crop conditions are normal, and State Directors are charged with the responsibility of closing sales immediately in any county when abnormal crop conditions develop. Experience revealed that under the original policy major increases in participation were resulting whenever farmers judged crop prospects were swinging the insurance odds rather strongly in their favor. Sound operating policy made it imperative to stop sales when crop prospects were poor.

At the start there was no minimum requirement for participation in order for the insurance to be in effect in a county. Legislation was changed to provide minimum requirements but was later amended to eliminate these requirements. (4)

Recent developments in commercial crop insurance

In recent years, weather-perils crop insurance has been written by a few private crop-hail companies. The volume, however, is estimated at only about one-tenth of 1 percent of all crop-hail coverage and is mainly limited to corn and soybeans in the Corn Belt. It is rarely available where drought or other weather risks are severe, such as in the Great Plains. Apparently, the commercial companies regard weather-perils crop insurance as still largely experimental for the purpose of developing actuarial experience and of testing market demand. Although loss ratios have been higher with weather-perils insurance than with crop-hail insurance, the loss ratios of the former have improved in recent years.

For one commercial company selling multiperil crop insurance on corn and soybeans in the Corn Belt, the coverage was restricted to growers who also had crop-hail insurance. The amount they could collect was limited to half the crop-hail coverage and was subject to a 50-percent deductible. The company protected itself against possible concentrated area losses by setting maximum area and State quotas on the volume of insurance it would accept. These various safeguards were used because of the newness of the policy and the relative lack of experience with it. Despite the small volume of all-risk crop insurance written by the private insurance industry, there has been cautious interest shown in expanding the business by both mutual and stock companies. An actuarial association of crop-hail stock companies developed a multiperil policy for use in five States in 1969. According to information available, the insurance coverage, premium rates, and other features are similar to those of the Federal crop insurance.4/ The new policy is sold either as a single policy, including crop-hail protection, or as an endorsement to a crop-hail policy. The new insurance was available in 1969 on tobacco in North Carolina, on wheat and barley in Washington, and on corn and soybeans in Iowa, Illinois, and Indiana. Since then, multiperil crop insurance has become available from private stock companies in Arizona, Montana, Virginia, South Carolina, Georgia, Tennessee, and Kentucky.

The possibility of catastrophic losses with all-risk insurance continues to be the main concern of private companies. Some of the companies would like the Federal Crop Insurance Corporation to reinsure their all-risk policies; some believe that a study should be made to determine whether the industry itself can spread the risk through pooling the risks or other arrangements.

PARTICIPATION IN CROP INSURANCE

In this section we discuss the area and extent of use of the two major kinds of crop insurance--private crop-hail and Federal all-risk crop insurance. With regard to the latter, we show the participation by crops, regions, and selected counties, ending with a discussion of the characteristics of the participating users.

Commercial Crop-Hail Insurance

More than half a million farms--about one of six U.S. farms--are insured with commercial crop-hail insurance. The number of hail insurance policies exceeds the number of insured farms because landlord and tenant may each insure their financial interest in the crop. Total insurance protection purchased in 1969 was $3,550 million, at a total premium cost of $127 million. The losses paid were $80 million. Crop-hail insurance has expanded greatly in the last 35 years (table 1) (6).

Insurance against hail damage to growing crops is available and is used in all areas of the country where the risk is significant. Participation in crop-hail insurance depends not only upon the incidence of hail-storms but also upon the value of the crop grown and its susceptibility to hail damage. Participation in the Great Plains varies somewhat according to early season crop prospects. In a year of drought, for example, growers feel less need for hail protection. In a year when crop prospects are good, many wheat farmers buy private crop-hail insurance to supplement the insurance coverage they may have with Federal all-risk crop insurance.

4/ Based on an article in the National Underwriter, December 27, 1968, and March 6, 1970.

About four-fifths of the crop-hail insurance coverage is sold in 12 States--4 in the Corn Belt, 3 in the Great Plains, plus Minnesota, North Carolina, Texas, Wisconsin, and Washington (table 2).

Tobacco is one of the crops most susceptible to hail damage and a fifth of the crop is usually insured.

About one-fourth of the wheat acreage is insured by crop-hail insurance. Hailstorms are relatively frequent in the Great Plains where much wheat, other small grains, and grain sorghum are grown. In fact, the Great Plains accounts for about one-fifth of all crop-hail insurance.

Approximately one-fifth of the corn and soybean acreage is protected by crop-hail insurance. Although the probability of hail in the Corn Belt is less than in the Great Plains, severe financial losses occasionally occur because of the large investment in and value of the crop. Premium rates are comparatively low and many Corn Belt growers buy continuous hail policies, much as they do fire and wind insurance on their buildings. More than half the dollar value of all crop-hail insurance written in the United States is bought in the Corn Belt States of Ohio, Indiana, Illinois, Iowa, and Missouri.

Crop-hail insurance is important on corn, wheat, and other grains in parts of the Lake States region and on cotton in sections of the South. Protection also is frequently used in some areas on crops such as sweet corn, canning peas, and fruits.

Federal Crop Insurance

Approximately 300,000 farms, roughly 10 percent of all U.S. farms, are insured each year. Federal crop insurance is available for 24 different crops in about half the rural counties. Total insurance protection in 1969 was $908 million, compared with $872 million in 1968 and $243 million in 1958. Indemnities paid for crop losses fluctuate from year to year depending upon growing conditions. The record $56 million in losses in 1969 were substantially above the $25 million losses as recent as 1966.

Participation by crops

Five crops--wheat, tobacco, corn, cotton, and soybeans--accounted for about 80 percent of the total insurance in force in 1968 (table 5).

Insurance on wheat was largest, accounting for coverage of $216 million and 77,000 contracts.[5] Tobacco was next with $143 million and 66,000 contracts. About 71,000 corn contracts were written for a total of $142 million. Insurance on cotton and soybeans totaled $132 million and $72 million, respectively.

5/ Two or more contracts protecting the interests of both landlords and tenants may occur on farms in which land is rented.

About 27 percent of the tobacco acreage eligible for insurance was covered in 1968, the largest proportion for any of the five leading crops. The percentage of eligible acreage insured was 18 percent for wheat, 16 percent for cotton, 8 percent for corn, and 6 percent for soybeans. Nearly 56 percent of the eligible green pea acreage was insured. The percentages for some specialty crops were: tung nuts, 14 percent; peaches, 25 percent; apples, 18 percent; and tomatoes, 18 percent. For all crops as a whole, about 12 percent of the insurable acreage was insured.

Participation by regions

The FCI program, although limited by law, is available in the major crop areas, particularly where production risks are relatively high.

About 65 percent of the 362,000 FCI contracts in 1968 were in four regions--the Lake States, the Corn Belt, the Northern Plains, and Appalachia (table 6). Leading States in order of number of contracts or of amount of insurance are North Carolina, Minnesota, Iowa, North Dakota, Kansas, California, and Texas (table 7). Little or no Federal crop insurance is sold in the northeastern States, West Virginia, Nevada, and Utah.

The importance of Federal crop insurance in selected States for the five leading crops is shown in table 8. The highest proportion of eligible wheat acreage insured in 1968 was 31 percent in Montana, 28 percent in Colorado, and 25 percent in North Dakota. In Colorado, where FCIC withdrew from several high-risk counties in the 1950's, 16 percent of all planted wheat acreage was insured. Only about 7 percent of the eligible wheat acreage and 1 percent of the planted acreage in Texas was insured.

Federal crop insurance protected 22 percent of the eligible corn acreage and 23 percent of the eligible soybean acreage in Minnesota, but percentages insured in the main Corn Belt States were relatively small. Eligible corn acreage insured ranged from about 9 percent in Iowa to 2 percent in Illinois. Soybean acreage insured ranged from 9 percent in Iowa to 2 percent in Missouri and Iowa.

A fourth of the eligible cotton acreage in Arizona and New Mexico and half of it in Alabama was insured by the FCIC. But in Mississippi and Arkansas only 10 and 11 percent, respectively, of the eligible cotton acreage was insured.

More than a fourth of the eligible tobacco acreage in the six major tobacco States was insured. Virginia and North Carolina were highest with 48 and 34 percent of the acreage protected. Georgia showed the smallest participation, 13 percent.

Participation in selected sample counties

An important question is who participates in Federal crop insurance. Is it the small farmer, the large farmer, or a broad cross-section of farm operators? Is it the tenant farmer or the owner-operator?

To determine participation, the distribution of FCI contracts in 21 sample counties, well distributed geographically, in areas producing wheat, corn, soybeans, cotton, and tobacco was studied. The sample counties have somewhat higher-than-average participation, hence they may represent the pattern of participation that could be expected under an expanded program. With the help of the FCIC agent in each county, we were able to identify those contracts held by farm operators and those held by landlords. We also ascertained the total acreage insured by each operator or landlord. In the wheat, corn, and soybean counties we had U.S. census numbers of farms classified by acres of crop with which to compare the number of FCI participants.

We may summarize our findings in the 21 sample counties as follows:

(1) All tenure groups--owners, part-owners, tenants, and landlords--use FCI though not uniformly so. Because FCI participation is higher in one tenure group in some counties and lower in others, we must conclude that tenure does not generally influence participation.

(2) Landlords had one-fourth of the FCI contracts ranging from an average of 20 percent in the four cotton counties to 35 percent in the five wheat counties. Degree of landlord participation varied widely among the counties with no consistent pattern relating to crop or geographic area.

(3) FCI participation is widely distributed among farm operators having a wide range of crop acreages. Even so, FCI participation seems to be greater among the larger acreages in wheat and corn, and among the smaller acreages in soybeans and cotton.

We conclude therefore that FCI participation is widely distributed among tenure groups and size of operation. It remains to explore the results in groups of counties, by crop.

Wheat counties--Sample counties include Chouteau, in the Montana triangle; Bottineau in northwest North Dakota; Deuel in southwest Nebraska; Phillips in northeast Colorado; and Sherman in western Kansas.

Among the farm operators, FCI participation was highest in Phillips (80 percent), a county in which some lenders reportedly urge their farmer-borrowers to insure with FCIC. Farm operator participation was about 60 percent in Bottineau, and Deuel, and about 40 percent in Sherman.

FCI participation was well distributed among operator tenure groups, though not in the same pattern in each county (table 9). We could detect no general tendency for any tenure class to have greater participation than another.

FCI participation was also well spread over size groups according to acres of wheat (table 9). However, the density of participation was lowest among growers having less than 50 acres of wheat in all five sample counties. The highest percentage of FCI participation was among operators having over 100 acres of wheat in Chouteau, Bottineau, and Phillips. But participation was slightly higher among operators with 50 to 99 acres of wheat in Deuel and Sherman.

Landlords accounted for about 20 percent of all FCI contracts in Chouteau, and for 35 to 40 percent of all contracts in the four other sample counties. Lacking data on number of all landlords, we were unable to compute the percentage that participated. However, the ratio of landlord participants to part owner and tenant participants was about 1 to 3 in Chouteau, 5 to 6 in Bottineau, 1 to 1 in Deuel, 3 to 4 in Phillips, and 2 to 3 in Sherman. In general, the wheat acreage insured by landlords tended to be a bit smaller than that insured by farm operators (table 9).

Corn counties--Sample counties include Goodhue in southeast Minnesota, Buena Vista in northwest Iowa, LaSalle in north-central Illinois, and Logan in northwest Ohio. These sample counties are in the heart of the corn-producing area in each State.

Among farm operators, FCI participation was considerably higher in the Buena Vista, Iowa (36 percent), and Goodhue, Minnesota (30 percent), than in Logan, Ohio (20 percent) and LaSalle, Illinois (6 percent) (table 10). In Goodhue and Buena Vists, participation tended to increase with acreage of corn per farm. But in Logan, it was highest in the middle-size range.

FCI participation by operators and landlords tended to be heaviest in the same corn acreage groups. The ratio of landlord participants to part owner plus tenant participants was about 3 to 4 in Goodhue, 4 to 5 in Buena Vista and Logan, and 1 to 3 in LaSalle. In Buena Vista, 2 of 5 of the landlords were widows or other females who had an insurable interest in the corn crop.

Soybean counties--Sample counties include Faribault, Minnesota; Ida, Iowa; Henry, Indiana; and Bolivar, Mississippi.

Farm operator participation was highest in Ida (34 percent) and Faribault (27 percent). Participation was under 15 percent in Henry and Bolivar. There was substantial FCI participation in all farm operator tenure classes except in Bolivar where almost all participants were full owners. FCI participation was by far the heaviest among growers having under 49 acres of soybeans (table 11).

Landlord FCI participation was relatively light in the soybean counties. However, the ratio of landlord participants to part owner and tenant participants was about 1 to 2 in Faribault and nearly 1 to 1 in Ida and Henry. Bolivar had no landlord participants.

Cotton counties--Sample counties include Tulare, California; Lubbock, Texas; Holmes, Mississippi; and Madison, Alabama (table 12).

FCI participation represented about a fourth of the operators in Tulare, a sixth in Lubbock and Madison, but only one-twentieth of those in Holmes. The participants were mostly full owners in Tulare, Holmes, and Madison and heavily tenant operators in Lubbock.

In Tulare, most of the operator participants had less than 100 acres of cotton; the largest number had 20 to 49 acres. In Lubbock, the majority of farm operator participants had between 20 and 200 acres of cotton. In Holmes and Madison, about one-half of the operator participants had less than 20 acres.

Tulare had relatively few landlord FCI participants, and Holmes had none. In Lubbock and Madison, the ratio of landlord participants to part owners and tenant participants combined was roughly 2 to 3.

Tobacco counties--Sample counties include Breckinridge, Kentucky; Robertson, Tennessee; Pittsylvania, Virginia; and Beaufort, North Carolina (table 13). The first two counties grow burley tobacco and the last two, flue-cured.

About 35 to 45 percent of the tobacco farm operators in Breckinridge, Robertson, and Pittsylvania, and 65 percent of those in Beaufort had FCI contracts on their tobacco crop. They tended to be full owners in Breckinridge, Robertson, and Beaufort, and tended to be tenant operators in Pittsylvania.

While the farm operator participants were widely distributed as to acreage of tobacco per farm, the largest number had 0.5 to 1.5 acres in Breckinridge, 2.0 to 5.0 acres in Robertson, 3.0 to 10.0 acres in Pittsylvania, and 5.0 to 20.0 acres in Beaufort.

From 20 to 30 percent of all FCI contracts on tobacco were held by landlords in the four counties. The landlord contracts tended to be widely dispersed among acreages of tobacco, except in Breckinridge County where they were among the smaller acreages.

Characteristics of participants according to other studies

Studies in various farming areas reach different conclusions as to the characteristics of the persons who buy Federal crop insurance.

In southern Virginia, the insured tobacco growers were smaller in size and income, more specialized, used less irrigation, and were more indebted than the uninsured. A survey in the High Plains of Texas also showed participants, with some exceptions, to have the smallest acreage, lowest total net income expectations, and the largest liabilities. Studies in Montana and North Dakota suggest that insured growers were less likely to have livestock, financial, or grain reserves, and were more frequently in debt.

Another North Dakota study, however, showed that fewer FCI participants than nonparticipants had debts. The insured tended to be the larger operators in the low- and medium-risk areas, but tended to be smaller operators in the high-risk area.

Still other surveys reveal that the bigger, better-fixed farmers mainly use Federal crop insurance. In western Nebraska, where FCI premium rates are relatively high, the researcher states: "Federal crop insurance appears to have enrolled the larger farmers with more businesslike management who are willing to sacrifice the cost of premium for protection. The smaller farmers who feel they cannot afford the premiums. . .are more likely to drop out of the program" (7).

A Colorado study and a second report for Montana point out that participation characteristics vary widely, a finding evident in all the studies.

Loftsgard, who summarized the FCI studies made in several of the Great Plains States, says: "A comparison of these characteristics, for farmers who participate versus those who are not participating in the program, reveals little. In some areas it was found insured farmers had a better financial position than the uninsured. In different areas the opposite result was true. A similar situation was found concerning farm size and many other characteristics studied, in that no particular pattern of significant differences was evident. Some exceptions to this conclusion were evidenced in Montana; but for all states studied, the only consistency observed was that participants are slightly older and rely more heavily on cash-grain income than the nonparticipants" (7).

The farm size distributions of: (1) all farms, (2) farms using crop insurance (of all kinds), and (3) farms using Federal crop insurance are shown for a general survey sample of 6,119 U.S. farms in table 14. Since the survey was limited to farm operators, the data do not include the crop insurance users who were non-operating farm landlords.

Overall, about 41 percent of the sample farms had some form of crop insurance in 1966. The smallest percentage of use was 10.6 percent in the group hav-having volume-of-sales under $2,500 per farm. The percentage increased up to 51.5 percent in the sales group of $40,000 to $99,999, but dropped back to 43.7 percent among the farms with sales of $100,000 and over.

Overall, about 1 of 8 sample farms had Federal crop insurance. Again, the percentage was lower in both the smallest and the largest sales groups. The percentage of users increased from 10.8 percent in the $2,500-$5,000 sales group up to 18.2 percent in the $10,000-$20,000 sales group, then dropped back to 11.3 percent in the $40,000-$100,000 sales group.

Since farm size (volume-of-sales) tends to run larger in some types of farming and some regions, the data have limitations. However, the data suggest somewhat heavier use of FCI among the medium-sized farms and somewhat lighter use among the smaller and the larger farms (table 14).

CHARACTERISTICS OF CROP INSURANCE

In this section we outline the general characteristics of the two main types of crop insurance--crop-hail and all-risk (multiperil). Anyone desiring specific information on programs, policies, premium rates, and rules should contact the FCIC or the private insuring agencies directly.

Commercial Crop-Hail Insurance

Commercial crop-hail insurance protects against crop loss due to hail or a combination of hail and wind; some policies also cover crop loss due to fire. Insurance coverage is offered in dollar amounts per acre up to the reasonable value of a full yield, with the premium scaled accordingly.

The premium charge per acre is based not only on the amount of insurance coverage per acre, but also on the probability of occurrence of hail, and the probable degree of damage, factors which in combination indicate the probable indemnities. In addition to covering the probable indemnities, premiums are set to cover operating costs and to return a profit. Actuarial data are mainly statistics on hail-loss adjustments pooled from the experience of insurance companies.

The indemnity is based on the percentage of the crop damaged by hail. Damage is measured in terms of stand reduction or percentage of grain heads or corn ears lost, and so on. The damage is assessed by the insurance company soon after the event, so it can be isolated from other causes. The indemnity is computed as the percentage of damage times the insured value, usually without regard to the actual value of the crop.

Crop-hail insurance can be bought at any time, from before seeding to the day before harvest. In the Great Plains, wheat growers often wait until crop prospects are nearly assured before they buy crop-hail insurance. Then they buy coverage commensurate with the prospective yield--high coverage where crop prospects are excellent, little or no coverage if prospects are poor. Outside the Great Plains, many farmers buy hail insurance on a continuing basis as they do fire insurance on their buildings.

Federal All-Risk Crop Insurance

Federal all-risk insurance, as the name indicates, protects the crop against losses due to "unavoidable causes, including drought, flood, hail, wind, frost, winterkill, hurricane, tornado, insect infestation, plant diseases, and such other unavoidable causes as may be determined by the Board."6/ In some cases it also protects against loss of crop quality due to natural causes (e.g., soft corn). In the case of drying raisins, the protection is limited to loss due to rain damage (11). FCI does not protect against crop loss due to poor management or poor husbandry. The crops and number of counties in which FCI is available is controlled by law. Currently FCI is available on 24 crops in about half the counties of the United States.

The purpose of Federal all-risk crop insurance is to enable farmers to recover their production expenses (their investment in the crop) rather than compensate them for the full value of the crop. Hence, FCI coverage is limited by law to the usual expense of crop production, not to exceed 75 percent of the county (or area) average normal yield. As a consequence of this provision, the extent of

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6/ Agriculture Handbook No. 361, January 1969, p. 273.

insurance coverage varies widely among crops inasmuch as the production expenses vary from about 30 percent of the gross on wheat to about 60 percent on soybeans, cotton, and tobacco. Usually, the contract provides insurance coverage (yield guarantee) equivalent to the usual preharvest production expenses. If a partially damaged crop is harvested, the bushel guarantee is increased to cover harvesting costs as follows:

Crop	Bushel increase
Wheat	1.5 bu.
Barley	2.0 bu.
Corn	3.0 bu.
Soybeans	1.5 bu.

A yield guarantee is established by the Corporation for the crop in each county or part of a county and with one to three product price options selected by the insured. For tobacco, the guarantee is in the form of a minimum crop value per acre--a combination of both yield and quality.

The premium charge per acre is based on the price option selected and on the probability of the yield falling below the yield (or value) guarantee. The premium is set to cover only the anticipated indemnities and to build up a reserve. In computing premiums the operating expenses of the Corporation may not be included.7/ The FCI premium of a farmer may be reduced after his policy has been in effect for 2 years and he has filed no claims. The schedule of premium discounts earned by consecutive years (up to 7 years) without a loss claim are:8/

Percent premium rate reduction	Consecutive years with no loss
5 percent after	1 year
5 percent after	2 years
10 percent after	3 years
10 percent after	4 years
15 percent after	5 years
20 percent after	6 years
25 percent after	7 years and over

The possibility of earning reduced premium rates discourages farmers from reporting inconsequentially small losses. Reduction in premium rates is probably more common among farmers whose yields are above average.

7/ Congress has ruled that loss adjustment is not an operating expense, hence may be paid from premium revenue, though not included in computing premium rates.

8/ From Federal Register of November 21, 1967 (32 F. R. 15911).

Indemnities are based upon the difference between the yield guarantee and the harvested yield (if any). For this purpose, the yield is averaged on all acres (fields) of the same insured crop on the farm. Thus, even though the crop on some acres might fail utterly, there would be no indemnity if the average yield on the farm equals the yield guarantee.

The indemnity is computed at the unit-price option originally selected by the purchaser. For some crops the indemnity may be increased to compensate for cost of harvesting, but not in the case of total loss when there is no harvest. Indemnities are not settled until after all the acreage of the insured crop on the farm is harvested (harvested production is proof of loss) except when the entire acreage of the crop is a total failure. If the insured crop is destroyed early in the growing season, an indemnity may be paid depending on the basis of whether the field is replanted to the same or a substitute crop.

FCI must be purchased before a specified closing date, at seeding time or before. Sometimes the Corporation will suspend the sale of insurance even earlier if drought occurs and new policy applications in an area become heavy. However, regular policies remain continuously in force subject to cancellation by the insured or the FCIC. Cancellation must precede a specified date. A reinstated policy is a new policy with respect to premium rate discount.

Comparisons

Crop-hail insurance and Federal all-risk insurance differ significantly in several ways:

(1) Insurance coverage. Private crop-hail can be bought with the yield and dollar coverage preferred by the user up to the full value of the expected crop. FCI coverage is limited to one yield guarantee in any designated area or county; the user may have up to three unit price options with his guarantee. The crop-hail is flexible in that it can be readily used as supplemental coverage to other insurance such as FCI, or to supplement other strategies used to combat risk. If alternative yield guarantees were offered in FCI, it would become more flexible from the standpoint of farmer users.

(2) Date of purchase. Crop-hail can be purchased at any time up to harvest whereas FCI must be purchased at or before crop planting time--as it must, since it insures against all risks.

(3) Premium revenue. Private crop-hail expects premium revenue to pay indemnities, build reserves, pay operating costs and return a profit. FCI expects premium revenue only to pay indemnities (including loss adjustment) and to build reserves; the Government finances FCIC operation expenses and the Corporation is, of course, nonprofit.

(4) Indemnities. Crop-hail indemnifies the farmer for that portion of his growing crop that is lost because of hail or fire. Loss

adjustment is a matter of determining that percentage of the crop lost, and is not concerned with the actual yield as such. Indemnities are based on the loss percentage times the contracted insurance coverage. In contrast, FCI indemnifies for the amount by which the actual yield falls below the insured or guaranteed yield. Adjustment is a matter of determining the actual yield, proof of which is the harvested yield. FCI computes indemnities on the average yield for the entire farm whereas crop-hail computes and pays indemnities on individual acres damaged or destroyed.

(5) Inclusive acreage. All of the fields and acres of the insured crop on the farm must be included in an FCI contract. Crop-hail insurance can be purchased for any one or as many fields as the purchaser chooses.

ALL-RISK INSURANCE COVERAGE AS RELATED TO FARM OPERATOR'S CASH CLAIMS

In designing crop insurance programs it should be noted that farm operators may differ widely as to their financial status and hence as to the cash claims they hope to meet from their crop income. In addition to cash production expenses, there may be cash rent, debt amortization payments, family living or educational expenses, and the like. At least some farm operators may wish their crop insurance to cover one or more of these additional cash claims.[9] These reasons suggest a flexible insurance program that would offer the users a choice of yield guarantees depending upon their individual circumstances.

Accordingly, in the present section we consider some of the more common cash claims that farmers may assign to their crop income. Then we compute the insurance coverage in terms of a yield guarantee necessary to cover these additional cash claims as well as cover ordinary production expenses.

Basis for Analysis

Our analysis is for wheat, corn, soybean, cotton, and tobacco enterprises in 10 counties (table 15).

In budgeting cash production expenses, we include all variable expenses plus a charge for all labor which we assume to be hired, and we include the crop insurance premium. These expenses must be met each year and can be considered cash claims against crop income. We have included all preharvest and harvesting expenses, as we assume that seldom would the crop be too poor to harvest. Production expenses are consistent with the yields.

9/ Readers are reminded that the Federal all-risk crop insurance coverage is limited by law to the ordinary production expenses, not exceeding three-fourths of the average yield.

Cash rent is a cash claim against the crop income of the cash-renting tenant and can be included in computing the yield guarantee. Likewise, land mortgage amortization payments can be considered cash claims against crop income. We have estimated the part of such payments that might be assigned to an acre of the insured crop for three levels of owner equity: 20, 50, and 80 percent.

Finally, we have computed the total crop value at the expected price and the average projected yield of the crop. The expected price is assumed equal to the weighted average level of price-supported crops in 1968. The projected yield is our own estimate based upon a least-squares trend of the county average yield.

In computing the yield guarantees per acre that would be required to cover specified cash claims, we have divided the specified cash claim by the unit price (including price supports) actually expected. Thus, an indemnity would become payable whenever the crop return falls below the cash claim. If in this computation we should use a higher-than-expected unit price, we would derive a lower per acre yield guarantee, in which case the crop return could fall below the cash claim before an indemnity became due. With a lower-than-expected unit price, the converse would be true.

Summary of Results

The results of our analysis can be indicated by the following ranges in per acre coverage needed--the smaller number in each pair being equal to production expenses:

		Dollars	Yield Guarantee
Wheat:	Chouteau, Mont.	16 - 53	9.4 - 32.0 bushels
	Sherman, Kans.	19 - 48	11.1 - 27.0 bushels
Corn:	Goodhue, Minn.	50 - 100	40.0 - 80.0 bushels
	La Salle, Ill.	58 - 125	46.4 -100.0 bushels
Soybeans:	Faribault, Minn.	36 - 65	14.4 - 26.0 bushels
	Henry, Ind.	41 - 71	16.4 - 28.0 bushels
Cotton:	Holmes, Miss.	130 - 290	335 - 860 pounds
	Madison, Ala.	125 - 210	365 - 615 pounds
Tobacco:	Breckinridge, Ky.	650 - 1145	not applicable
	Beaufort, N.C.	500 - 950	not applicable

Interestingly, the production cash expenses range from 29 to 66 percent of the gross return depending upon the crop.

Wheat farms

The analysis includes three sizes of wheat enterprise in each of Chouteau County, Montana, and Sherman County, Kansas.

In Chouteau County, Montana, the crop value at the projected yield of 32 bushels and the expected price of $1.65 is $52.80 an acre. Cash production expenses range from $17.50 an acre for wheat enterprise of 150 acres to $15.50 an acre for one of 500 acres (table 15). Cash rent averages $12.50 an acre, and debt amortization payments range from roughly $5 to $20 an acre depending upon the owners equity. From these data we can summarize the insurance coverages needed per acre to cover various combinations of cash claims as follows:

	Dollar coverage	Yield guarantee, bushels
Production cash expense on:		
Large farm, owner	$15.50	9.4
Medium farm, owner	16.00	9.7
Small farm, owner	17.50	10.6
Cash expense (medium farm) plus:		
Cash rent	$28.50	17.3
Debt payment, high equity	21.00	12.7
Debt payment, medium equity	28.00	17.0
Debt payment, low equity	36.00	21.8
Total crop value at projected yield	$52.80	32.0

In Sherman County, Kansas, total crop value at the projected average yield of 27 bushels and a price of $1.75 a bushel is about $46 an acre. Cash production expenses average about $19 an acre. Cash rent averages $12.50 an acre, and debt amortization payments range from $5 to $20 an acre depending upon the owners equity and the size of his mortgage (table 15).

We can summarize the insurance coverages needed per acre as follows:

	Dollar coverage	Yield guarantee, bushels
Production cash expenses on:		
Large farm, owner	$19.50	11.1
Medium farm, owner	19.00	10.9
Small farm, owner	19.50	11.1
Cash expense (medium farm) plus:		
Cash rent	$31.50	18.0
Debt payment, high equity	24.00	13.7
Debt payment, medium equity	31.00	17.7
Debt payment, low equity	39.00	22.3
Total crop value at projected yield	$47.25	27.0

Corn farms

The analyses are for 200-acre corn enterprises in Goodhue County, Minnesota, and in LaSalle County, Illinois.

In Goodhue County, total crop value at the projected yield of 80 bushels and the expected price of $1.25 is about $100 an acre. Cash production expenses are estimated at $50 an acre, and cash rent is $27. Debt amortization payments range from about $7 to $28 an acre (table 15).

We can summarize the insurance coverage needed per acre as follows:

	Dollar coverage	Yield guarantee, bushels
Production cash expenses	$ 50	40.0
Cash expenses plus:		
Cash rent	77	61.6
Debt payment, high equity	57	45.6
Debt payment, medium equity	68	54.4
Debt payment, low equity	78	62.4
Total crop value at projected yield	$100	80.0

In LaSalle County, Illinois, total crop value at the projected yield of 100 bushels and the expected price of $1.25 is $125 an acre. Cash production expenses are estimated at $58 an acre, and cash rent is about $40. Debt amortization payments range from about $10 to $40 an acre depending upon the equity and size of mortgage (table 15). We summarize the insurance coverage needed per acre as follows:

	Dollar coverage	Yield guarantee, bushels
Production cash expenses	$ 58	46.4
Cash expenses plus:		
Cash rent	98	78.4
Debt payment, high equity	68	54.4
Debt payment, medium equity	83	66.4
Debt payment, low equity	98	78.4
Total crop value at projected yield	$125	100.0

Soybean farms

In Faribault County, Minnesota, the total crop value of soybeans at the projected yield of 26 bushels an acre and the expected price of $2.50 is about $65 an acre. Cash expenses for producing soybeans are estimated at $36 an acre, and cash rent is about $20 on soybeans. Debt amortization payments range from about $5 to $20 an acre depending upon the owner's equity and the size of mortgage (table 15).

We can summarize the insurance coverage per acre needed in various circumstances as follows:

	Dollar coverage	Yield guarantee, bushels
Production cash expenses	$36	14.4
Cash expenses plus:		
Cash rent	56	22.4
Debt payment, high equity	41	16.4
Debt payment, medium equity	48	19.2
Debt payment, low equity	56	22.4
Total crop value at projected yield	$65	26.0

In Henry County, Indiana, the total crop value of soybeans is estimated at $70 an acre based on a projected yield of 28 bushels an acre and an expected price of $2.50 a bushel. Cash production expenses are estimated at $41 an acre, and cash rent is estimated at $25 an acre. Debt amortization payments vary from about $8 to $24 an acre.

We may summarize the insurance coverage and yield guarantees per acre needed to cover specified cash claims as follows:

	Dollar coverage	Yield guarantee, bushels
Production cash expenses	$41	16.4
Cash expenses, plus:		
Cash rent	66	26.4
Debt payment, high equity	49	19.6
Debt payment, medium equity	57	22.8
Debt payment, low equity	65	26.0
Total crop value at projected yield	$70	28.0

In the two soybean counties (Faribault and Henry), the insurance coverage needed ranges from 55 to 95 percent of the total crop value.

Cotton farms

The analyses are for Holmes County in the Mississippi Delta, an area of large cotton farms, and Madison County, Alabama, where the cotton farms tend to be small.

In Holmes County, total crop value is estimated at $290 based on a yield of 860 pounds of lint at a price of 30 cents per pound, plus cotton seed valued at $32 an acre (table 15). The expenses of producing cotton in Holmes County vary from $120 to $140 an acre depending upon size of enterprise; cash rent is about $50 an acre. Debt amortization payments vary from $10 to $40 an acre. We can summarize the insurance coverage needed per acre as follows:

	Dollar coverage	Yield guarantee, bushels
Production cash expenses, medium farm	$130	385
Cash expenses, plus:		
Cash rent	180	535
Debt payment, high equity	140	415
Debt payment, medium equity	155	460
Debt payment, low equity	170	505
Total crop value at projected yield	$290	860

In Madison County, Alabama, total crop value is estimated at $210 an acre based on a yield of 620 pounds of lint and a price of 30 cents a pound plus cotton seed valued at $24. Production expenses range from $110 to $135 an acre depending on acres of cotton; cash rent is about $35 an acre. Debt amortization ranges from $8 to $32 an acre depending upon the equity. We can summarize the insurance coverage needed as follows:

	Dollar coverage	Yield guarantee, bushels
Production cash expenses, medium farm	$125	365
Cash expenses, plus:		
Cash rent	160	470
Debt payment, high equity	133	390
Debt payment, medium equity	145	425
Debt payment, low equity	157	460
Total crop value at projected yield	$210	615

In the two cotton counties (Holmes and Madison), the insurance coverage needed ranges from 45 to 75 percent of the total crop value.

Tobacco farms

The analyses are for Breckinridge County, Kentucky, and Beaufort County, North Carolina.

In Breckinridge County, total crop value per acre is estimated at $1,590 based on a current yield and prices. Estimated production expense, excluding a land charge, is about $645 an acre on the smaller acreages (table 15); the cash rent is about $500. Debt amortization payments range from $110 to $440 an acre. Thus, the insurance coverage needed ranges from $645 to $1,145 an acre, compared with a total crop value of about $1,590.

In Beaufort County, total crop value is estimated at $1,230 an acre. Cash production expenses are about $500. Cash rent is about $450 and amortization payments range from $95 to $375 an acre. Thus, the insurance coverage needed ranges from $500 to $950 an acre, or from 41 to 77 percent of the total crop value.

Table 1.--Hail insurance on growing crops: Coverage, net premiums, indemnities and loss ratio, United States, selected years, 1935-69 1/

Crop year	Insurance coverage	Net premiums 2/	Indemnities paid	Loss ratio 3/
	Million dollars	Million dollars	Million dollars	Dollars
1935	206	9.2	5.7	0.62
1940	243	9.2	3.6	.39
1945	938	42.1	24.2	.58
1948	1,288	53.7	28.5	.53
1949	1,240	55.2	26.8	.49
1950	1,057	40.1	16.7	.42
1951	1,371	53.9	36.2	.67
1952	1,589	65.5	34.9	.53
1953	1,776	69.4	49.8	.72
1954	1,897	72.6	54.5	.75
1955	2,067	77.2	44.7	.58
1956	2,117	78.1	73.1	.94
1957	2,410	95.4	57.9	.61
1958	2,452	103.8	54.6	.53
1959	2,456	98.8	45.3	.46
1960	2,495	103.0	59.9	.58
1961	2,422	96.8	66.8	.69
1962	2,658	109.0	81.3	.75
1963	2,831	111.2	72.6	.65
1964	2,903	112.5	72.1	.64
1965	3,096	117.0	73.9	.63
1966	3,173	115.0	56.9	.49
1967	3,488	124.6	88.2	.71
1968	3,535	128.4	69.2	.54
1969	3,550	126.8	80.4	.63

1/ By mutual and stock insurance companies and State hail departments.
2/ After cash discounts and dividends.
3/ Indemnities paid per dollar of premium income, computed before rounding.

Table 2.--Crop-hail insurance: Coverage, premiums, indemnities, 12 leading States, average 1967-68 1/

State	Insurance coverage	Premiums	Indemnities
	Million dollars	Million dollars	Million dollars
Illinois	989.0	15.7	10.2
Iowa	623.7	19.9	16.5
North Carolina	190.5	8.8	4.1
Indiana	146.4	2.5	1.0
Nebraska	141.1	9.6	7.2
North Dakota	140.7	10.5	4.7
Minnesota	138.1	8.3	4.2
Missouri	123.0	2.9	1.3
Texas	95.2	6.7	4.3
Kansas	92.1	5.7	4.3
Washington	76.3	1.3	.2
Wisconsin	75.3	1.6	.8
12 States	2,831.4	93.5	58.8
Other States	679.8	33.0	19.9
United States	3,511.2	126.5	78.7

1/ By mutual and stock insurance companies and State hail departments.

Table 3.--Insurance coverage, premium income and indemnities paid, Federal Crop Insurance Corporation, 1939-47

Year	Insurance coverage	Premium income		Indemnities paid		Loss ratio 1/
		Amount	Percentage of coverage	Amount	Percentage of coverage	
	Million dollars	Million dollars	Percent	Million dollars	Percent	Dollars
1939	34.5	3.4	9.9	5.6	16.3	1.64
1940	67.0	9.2	13.7	13.9	20.7	1.51
1941	101.7	11.3	11.1	18.9	18.6	1.68
1942	197.6	16.7	8.4	24.9	12.6	1.49
1943	244.4	18.2	7.5	33.2	13.6	1.82
1944			No insurance offered			
1945	148.2	9.4	6.3	23.2	15.7	2.48
1946	350.6	35.3	10.1	63.5	18.1	1.80
1947	420.9	43.8	10.4	35.2	8.4	.81

1/ Indemnities paid per dollar of premium income, computed before rounding.

Table 4.--Growth in Federal crop insurance program, 1948-69

Crop year	Counties	Acreage insured	Insurance coverage	Premium income	Indemnities paid	Loss ratio 1/
	Number	Million	Million dollars	Million dollars	Million dollars	Dollars
1948	324	8.9	154.0	12.7	6.8	0.54
1949	357	11.1	163.5	11.7	15.5	1.32
1950	549	15.3	240.4	14.1	12.8	.91
1951	730	16.2	317.5	19.1	21.3	1.12
1952	795	16.4	350.2	21.2	20.6	.97
1953	847	20.6	437.5	27.1	31.1	1.15
1954	803	16.5	354.6	22.7	28.0	1.24
1955	794	14.3	309.9	22.3	25.5	1.14
1956	805	14.4	306.7	22.1	27.9	1.26
1957	818	11.5	242.1	17.4	12.0	.69
1958	830	11.2	242.7	17.6	4.5	.26
1959	847	11.7	270.8	18.5	14.1	.76
1960	869	11.0	265.9	17.8	10.3	.58
1961	890	10.2	271.7	18.2	16.1	.88
1962	995	10.4	356.6	21.9	24.0	1.10
1963	1,094	13.1	497.0	30.4	23.5	.77
1964	1,187	14.6	540.6	33.9	30.4	.90
1965	1,214	15.3	591.1	36.0	40.8	1.13
1966	1,304	15.2	635.6	36.8	25.4	.69
1967	1,364	18.0	776.5	43.5	55.2	1.27
1968	1,395	18.7	872.5	48.9	51.0	1.04
1969	1,425	17.4	908.0	48.8	55.7	1.14
Total				562.7	552.5	.98

1/ Indemnities paid per dollar of premium income computed before rounding.

Table 5.--Selected data: Federal crop insurance, by crop, 1968

Crop	Coverage	Number of contracts 1/	Acres: Total planted 2/	Acres: Eligible for insurance	Percentage of eligible acres insured
	Million dollars	Thousands	Thousands	Thousands	Percent
Wheat	216.2	77.1	62,486	47,368	18.3
Tobacco	143.0	65.6	880	740	27.3
Corn	142.4	71.4	65,126	39,902	8.5
Cotton	132.2	27.1	10,912	6,488	16.3
Soybeans	71.7	50.4	41,104	31,295	6.4
Citrus	32.4	3.3	986	846	12.3
Grain sorghum	21.2	10.1	13,995	7,493	7.5
Raisins 3/	15.4	1.7	262	134	72.4
Peanuts	14.5	3.4	1,493	776	11.7
Sugarbeets	13.3	1.7	1,476	852	12.4
Barley	12.4	9.3	10,477	5,692	11.5
Oats	11.7	24.0	23,166	10,411	6.6
Combined crops	10.9	2.7	---	1,593	38.6
Green peas	6.3	2.4	500	192	55.7
Beans	6.1	2.7	1,484	658	13.7
Sugarcane	5.4	.4	577	252	16.7
Flax	4.4	6.6	2,183	1,836	14.2
Apples	3.4	.5	---	38	18.4
Peaches	2.7	.4	---	67	25.4
Rice	2.2	.2	2,367	975	1.9
Grapes	2.2	.3	---	40	15.0
Potatoes	1.0	.1	1,410	291	2.1
Dry peas	.8	.2	244	216	10.2
Tomatoes	.7	.2	374	22	18.2
Tung nuts	.04	4/	60	7	14.3
Total	872.5	361.6	5/241,300	5/158,050	11.8

1/ Two or more contracts protecting the interest of both landlords and tenants may occur on farms in which land is rented.

2/ Data for citrus is for 1967; data for combined crops included in individual crops; for apples, peaches, and grapes not available; for tung nuts estimated latest data.

3/ Relates to tons of raisins.

4/ Less than 100.

5/ Excludes raisins.

Table 6.--Selected data: Federal crop insurance, by regions, 1968

Region	Coverage	Number of Contracts 1/	Number of Eligible acres 2/	Number of Insured acres	Percentage of eligible acres insured
	Million dollars	Thousands	Thousands	Thousands	Percent
Northeast	8.6	3	1,404	139	9.9
Lake States	93.4	78	18,164	2,984	16.4
Corn Belt	126.4	72	51,724	2,584	5.0
Northern Plains	157.2	82	42,649	7,034	16.5
Appalachian	151.1	69	3,126	415	13.3
Southeast	61.0	15	2,924	390	13.3
Delta States	35.5	6	9,163	443	4.8
Southern Plains	49.6	14	11,927	1,093	9.2
Mountain	90.6	15	11,041	2,459	22.3
Pacific	99.2	8	5,928	1,167	19.3
United States	3/872.5	3/362	3/158,050	3/18,708	11.8

1/ Two or more contracts protecting the interests of both landlords and tenants may occur on farms in which land is rented.
2/ Acres eligible for Federal crop insurance.
3/ May not add to totals because of rounding.

Table 7.--Federal crop insurance: Coverage, premiums, indemnities, 12 leading States, average, 1967-69

States	Insurance coverage	Premium	Indemnities
	Million dollars	Million dollars	Million dollars
North Carolina	104.2	2.8	2.4
Minnesota	75.1	5.0	3.7
Iowa	69.3	3.2	2.1
North Dakota	60.1	3.9	1.7
Kansas	45.7	3.7	4.0
California	45.0	2.2	4.1
Texas	37.6	2.5	5.5
Montana	33.8	2.1	.8
Virginia	30.4	.9	.6
Nebraska	27.6	2.2	1.5
Washington	24.4	.9	2.1
South Carolina	19.5	.9	1.5
12 States	572.7	30.3	30.0
Other States	283.1	16.7	23.9
United States	855.8	47.0	53.9

Table 8.--Percentage of eligible acreage insured by FCIC, major crops in leading States, 1968

Crop and State 1/	Percentage insured
	Percent
Wheat	
North Dakota	25.4
South Dakota	21.5
Nebraska	17.7
Kansas	15.7
Oklahoma	10.3
Texas	6.7
Montana	31.2
Colorado	28.5
Total 8 States	19.6
Corn	
Michigan	2.8
Minnesota	22.3
Ohio	5.4
Indiana	4.8
Illinois	2.0
Iowa	9.2
Missouri	3.1
Nebraska	8.8
Total 8 States	7.9
Soybeans	
Minnesota	23.4
Ohio	5.3
Indiana	4.7
Illinois	2.1
Iowa	9.0
Missouri	2.1
Total 6 States	7.4
Cotton	
North Carolina	22.0
Alabama	48.7
Mississippi	10.2
Arkansas	10.6
Louisiana	13.7
Texas	13.4
New Mexico	26.5
Arizona	25.7
Total 8 States	16.1
Tobacco	
Virginia	48.3
North Carolina	34.0
Kentucky	15.2
Tennessee	17.3
South Carolina	20.0
Georgia	13.3
Total 6 States	27.7

1/ In 1968, the groups of States listed accounted for from 61 to 93 percent of the total planted acreage and from 71 to 96 percent of the total insured acreage for the respective crops.

Table 9.--Participation in FCIC wheat program in five selected counties, 1967 1/

Item	Chouteau, Mont.	Bottineau, N. Dak.	Deuel, Nebr.	Phillips, Colo.	Sherman, Kans.
			Number		
All wheat farms, 1964 2/	843	1,127	281	377	472
Operators with FCI contracts, 1967:					
Full owners	138	255	44	50	44
Part owners	231	294	78	169	72
Full tenants	65	150	58	83	71
Total	434	699	180	302	187
By acres of wheat:					
0-19 acres	---	8	0	0	0
20-49 acres	5	49	5	9	7
50-99 acres	18	108	32	36	31
100-199 acres	56	217	44	61	52
200-499 acres	156	282	76	133	52
500-999 acres	161	32	22	57	38
1,000 plus acres	38	3	1	6	7
			Percent		
As a percentage of all operators:					
0-49 acres	12	34	13	19	18
50-99 acres	41	60	82	61	46
100 plus acres	54	69	71	95	41
All operators	51	62	64	80	40
			Number		
Landlords with FCI contracts, 1967:					
By acres of wheat:					
0-19 acres	---	2	0	1	0
20-49 acres	3	50	0	7	5
50-99 acres	14	123	52	61	35
100-199 acres	29	146	52	67	28
200-499 acres	35	45	28	49	29
500-999 acres	15	1	3	4	3
1,000 plus acres	4	---	1	---	---
Total	100	367	136	189	100

1/ Based on special tabulations of FCIC data.
2/ From U.S. Census of Agriculture.

Table 10.--Participation in FCIC corn program in four selected counties, 1967 1/

Item	Goodhue, Minn.	Buena Vista, Iowa	LaSalle, Ill.	Logan, Ohio
	Number			
All corn farms, 1964 2/	1,902	1,463	2,617	1,085
Operators with FCI contracts, 1967:				
Full owners	476	183	45	121
Part owners	52	108	26	43
Full tenants	36	243	86	57
Total	564	534	157	221
By acres of corn:				
0-19 acres	97	11	2	39
20-49 acres	233	93	25	85
50-99 acres	168	252	69	59
100-199 acres	57	153	47	33
200-499 acres	9	25	14	4
500 plus acres	---	---	---	1
	Percent			
As a percentage of all operators:				
0-19 acres	22	22	2	11
20-49 acres	27	30	6	21
50-99 acres	34	37	8	27
100-199 acres	61	41	5	35
200 plus acres	100	49	7	22
All operators	30	36	6	20
	Number			
Landlords with FCI contracts, 1967:				
By acres of corn:				
0-19 acres	11	5	0	15
20-49 acres	38	95	9	40
50-99 acres	11	131	20	20
100-199 acres	6	41	6	6
200-499 acres	1	5	3	---
Total	67	277	38	81

1/ Based on special tabulations of FCIC data.
2/ From U.S. Census of Agriculture.

Table 11.--Participation in FCIC soybean program in four selected counties, 1967 1/

Item	Faribault, Minn.	Ida, Iowa	Henry, Ind.	Bolivar, Miss.
	Number			
All soybean farms, 1964 2/	1,711	716	884	940
Operators with FCI contracts, 1967:				
Full owners	244	126	37	131
Part owners	116	26	28	2
Full tenants	100	95	30	2
Total	460	247	95	135
By acres of soybeans:				
0-19 acres	20	38	18	53
20-49 acres	143	114	38	41
50-99 acres	180	79	25	14
100-199 acres	93	16	10	6
200-499 acres	22	---	4	14
500 plus acres	2	---	---	7
	Percent			
As a percentage of all operators:				
0-49 acres	45	43	13	24
50-99 acres	14	10	6	5
100 plus acres	7	---	6	6
All operators	27	34	11	14
Landlords with FCI contracts, 1967:				
By acres of soybeans:				
0-19 acres	7	11	14	0
20-49 acres	60	53	21	0
50-99 acres	52	33	14	0
100-199 acres	13	4	1	0
200-499 acres	2	2	---	0
Total	134	103	50	0

1/ Based on special tabulations of FCIC data.
2/ From U.S. Census of Agriculture.

Table 12.--Participation in FCIC cotton program in four selected counties, 1967 1/

Item	Tulare, Calif.	Lubbock, Texas	Holmes, Miss.	Madison, Ala.
	Number			
All cotton farms, 1964 2/	1,780	1,437	1,161	1,353
Operators with FCI contracts, 1967:				
Full owners	357	92	55	107
Part owners	51	35	1	90
Full tenants	22	116	0	57
Total	430	243	56	254
By acres of cotton:				
0-19 acres	109	35	32	112
20-49 acres	119	69	5	54
50-99 acres	101	80	6	45
100-199 acres	76	50	8	29
200-499 acres	20	9	5	13
500 plus acres	5	---	---	1
Landlords with FCI contracts, 1967:				
By acres of cotton:				
0-19 acres	19	7	0	65
20-49 acres	4	52	0	32
50-99 acres	5	30	0	10
100-199 acres	4	12	0	4
200 plus acres	1	3	0	1
Total	33	104	0	112

1/ Based on special tabulations of FCIC data.

2/ From U.S. Census of Agriculture.

Table 13.--Participation in FCIC tobacco program in four selected counties, 1967 [1]

Item	Breckinridge, Ky.	Robertson, Tenn.	Pittsylvania, Va.	Beaufort, N.C.
	Number			
All tobacco farms, 1964 [2]	1,414	1,382	3,377	1,176
Operators with FCI contracts, 1967:				
Full owners	283	250	369	464
Part owners	116	110	278	180
Full tenants	144	218	532	124
Total	543	578	1,179	768
By acres of tobacco:				
0-0.49 acres	27	13	---	1
0.50-0.99 acres	187	45	6	5
1.00-1.49 acres	135	39	39	10
1.50-1.99 acres	71	57	54	13
2.00-2.99 acres	60	146	166	61
3.00-4.99 acres	45	193	381	139
5.00-9.99 acres	18	71	329	270
10.00-19.99 acres	---	14	161	191
20.00 plus acres	---	---	43	78
Landlords with FCI contracts, 1967:				
By acres of tobacco:				
0-0.49 acres	9	6	---	---
0.50-0.99 acres	92	18	5	2
1.00-1.49 acres	61	25	24	4
1.50-1.99 acres	31	27	48	10
2.00-2.99 acres	27	55	110	40
3.00-4.99 acres	20	69	109	78
5.00-9.99 acres	5	34	90	54
10.00-19.99 acres	---	7	30	18
20.00 plus acres	---	---	---	3
Total	245	241	416	209

[1] Based on special tabulations of FCIC data.
[2] From U.S. Census of Agriculture.

Table 14.--Number and percentage of farm operators with crop insurance in 257 counties served by Federal crop insurance, 1966

(Pesticide and General Farm Survey, USDA)

Value of farm sales	Sample farms	Sample farms with crop insurance 1/		Sample farms with Federal crop insurance	
	Number	Number	Percent	Number	Percent
Less than $2,500	907	96	10.6	35	3.9
$2,500 to $4,999	380	104	27.4	41	10.8
$5,000 to $9,999	491	201	40.9	65	13.2
$10,000 to $19,999	1,817	830	45.7	331	18.2
$20,000 to $39,999	1,276	641	50.2	207	16.2
$40,000 to $99,999	1,003	517	51.5	113	11.3
$100,000 and over	245	106	43.3	20	8.2
Total	6,119	2,495	40.8	812	13.3

1/ Includes farms with Federal crop insurance.

Table 15.--Production cash expenses per acre and other typical cash claims against crop values, selected crops and areas, 1968

County	Acres of the crop	Production cash expenses	Cash rent	Debt amortization payment, when equity is			Total crop value
				20 percent	50 percent	80 percent	
	Acres	Dollars					
Wheat							
Chouteau, Mont.	150	17.50	12.50	20	12	5	53
	300	16.00	12.50	20	12	5	53
	500	15.50	12.50	20	12	5	53
Sherman, Kans.	50	19.50	12.50	20	12	5	47
	250	19.00	12.50	20	12	5	47
	500	19.50	12.50	20	12	5	47
Corn							
Goodhue, Minn.	200	50.00	27.00	28	18	7	100
LaSalle, Ill.	200	58.00	40.00	40	25	10	125
Soybeans							
Faribault, Minn.	100	36.00	20.00	20	12	5	65
Henry, Ind.	100	41.00	25.00	24	16	8	70
Cotton							
Holmes, Miss.	50	140.00	50.00	40	25	10	290
	100	130.00	50.00	40	25	10	290
	200	120.00	50.00	40	25	10	290
Madison, Ala.	10	135.00	35.00	32	20	8	210
	30	125.00	35.00	32	20	8	210
	50	110.00	35.00	32	20	8	210
Tobacco							
Breckinridge, Ky.	1.0	645.00	500.00	440	275	110	1,590
	5.0	590.00	500.00	440	275	110	1,590
	9.0	610.00	500.00	440	275	110	1,590
Beaufort, N.C.	2.0	500.00	450.00	375	235	95	1,230
	5.0	500.00	450.00	375	235	95	1,230
	15.0	510.00	450.00	375	235	95	1,230

PART II. ANALYTICAL CONSIDERATIONS

Many people view crop losses due to natural causes the way they view property loss or damage due to fire. Interestingly, fire insurance companies were the first to offer crop-hail insurance. The similarity is approximately true for crop-hail insurance, but not at all for all-risk crop insurance.

Fire losses tend to be randomly distributed over time and space, but more important, they have a low individual probability of occurrence. Among the many properties insured, a fire is a rare event. Thus, fire losses exhibit the statistical behavior of "extreme values," a theory concerned only with the probability of fire losses, and not with the distribution of those who do not have fires. Indemnities are based on specified property values, and the loss or damage thereto can be readily ascertained.

Crop-hail losses tend to behave like property fire losses. Though crop-hail losses are less randomly distributed, nevertheless their individual probability is relatively low. So, they too exhibit the statistical behavior of "extreme values," concerned only with the probability of hail loss claims and not with the distribution of those who do not have hail loss. Indemnities are based on the percentage of hail damage and the insured crop value, hence they are readily determined.

All-risk (multiperil) crop insurance is not limited to rare events such as property fire or hail damage. Instead, it insures against crop loss from any and all natural causes, thus increasing the probability that each insured crop will have a loss claim. Having some crop loss from at least one natural cause is not a rare event. Moreover, all-risk (multiperil) crop losses are measured against a guaranteed yield. The focus is on assuring a specified crop yield rather than on the crop loss due to a specific natural cause.

If the yield guaranteed is low, for example 25 percent of the average expected yield, a crop loss (yield below 25 percent) would be a rare event. And the statistical behavior would fall in the category of extreme values. But as the guaranteed yield is raised, the probability of a loss claim rises, and the statistical behavior shifts out of the category of extreme values into the category of central tendency.

If the yield guarantee equals the expected (average) yield, then half the acre yields can be expected to fall below the guarantee and to have a loss claim. The problem is one of estimating the probable distribution of individual yields below the mean average yield and below the guarantee. This is the theory of central tendency. We employ this theory in the analytical considerations of this study.

CROP YIELDS AND YIELD VARIABILITY

Because crop losses are highly erratic and tend to occur in bunches, all-risk crop insurance is more difficult for the insurer to manage than many other types of insurance programs. Crop hazards seldom affect a single farm in but one community, county, or State. Drought, excessive moisture, or frost may spread across broad areas, reducing the crop yield of every farmer within range, and generating a mass of claims in a single year. Nevertheless, all-risk crop insurers can ameliorate the problem in part by using the statistical tools of random distribution and central tendency. These tools are applicable to the analysis and projection of all-risk crop losses because such losses, measured as they are from a yield guarantee, obey the statistical behavior of central tendency.

Relevant to all-risk crop insurance are potential yields, actual yields, the actual variability from year to year, and the causes of yield variability among farms. We find three sources of yield variability: (1) the purely random causes, (2) crop production hazards, and (3) differences in management and in production strategies among farmers. Because of the last-named, farmers require insurance coverage (yield guarantee) that is adapted to their individual needs. Otherwise, a single level of coverage may be too high for one half and too low for the other half of the farm users in a production area.

Concepts

It is conventional to think of crop yields clustering around an average or norm as, for example, farm yields around the county average in a particular season, or the farm or county yields around a time-series average. The implication is that in any given year, all farm yields would tend toward the county average except for random factors, and that all annual yields would tend toward the time-series average except for production hazards. Thus, the average yield may be seen as a norm toward which all yields would tend, were it not for statistically random factors.

But we may look at crop yields another way, especially with regard to crop insurance. In this view, each planting may be seen as having the potential makings of a maximum crop unless or until natural hazards take their toll. This view assumes that for a specific (soil-climate) environment and a specified technology, there is a pure potential yield that would occur except for natural hazards and random factors. Because natural hazards do occur, the potential is seldom reached.

The concept of a potential yield is common not only among agronomists but also among farmers, particularly those in the Great Plains where drought is such a common hazard.10/ Many farmers in the Great Plains who believe they have at some time experienced the potential wheat yield refer to it when they consider crop insurance coverages, premium rates, and the like. Hence, the concept of a potential yield is relevant to crop insurance.

10/ Interestingly, Dr. E.A. Mitscherlich, a German agronomist, designed his control plots so they would not lack any element essential for plant growth. Thus, his experiments consisted of withdrawing successive units of one or more growth elements. In contrast, many U.S. experimenters assign the natural environment as the control plot, and the experiment consists of adding growth elements.

While we do not know what the potential yield is, we believe that in most instances it is considerably above the yields actually experienced by most farmers. On rare occasions when the season is perfect, no disease or insects appear, and "everything goes right," the actual yield experience may really approach the ultimate potential.

For discussion purposes, let us assume that the potential yield is located at P in figure 1. But because of many natural hazards, management, and other factors, most if not all yields actually experienced fall to the left of point P, the potential yield. Let us assume further that these actual yields average out at a point M_o (the mean of curve A_o) on the chart.

We should caution that the potential yield may not be the physically ultimate yield but rather the economic potential yield, when using the farming practices "that will pay."

The concept of a potential yield is perhaps most applicable to the individual production situation--the farm, but it is likewise applicable to a group of farmers who use the same production technology and the same economic strategy. Such conditions were perhaps more true, years ago, when production technology was more primitive (no fertilizers, no herbicides, etc.) and "nature" did most of the work.

Today, farmers have available a wide variety of production technology from which to choose depending upon their production style or management strategies. It is traditional to believe that farmers use the strategy of maximum total net profit in which they push the application of inputs to the extent that "it pays." If all farmers used this strategy, it would tend to minimize the variability of farm yields around the county average.

However, some farmers instead take a "least-cost" approach in which inputs are held to a modest level. In this case, total profit per acre may be lower than for the other group of farmers, but the return per dollar invested may be rather high. The least-cost policy may be adopted when farmers feel that natural hazards are great and therefore elect to spread their production investment over more acres. The least-cost strategy, we believe, is the typical production strategy of many wheat farmers, especially in the Northern Plains.

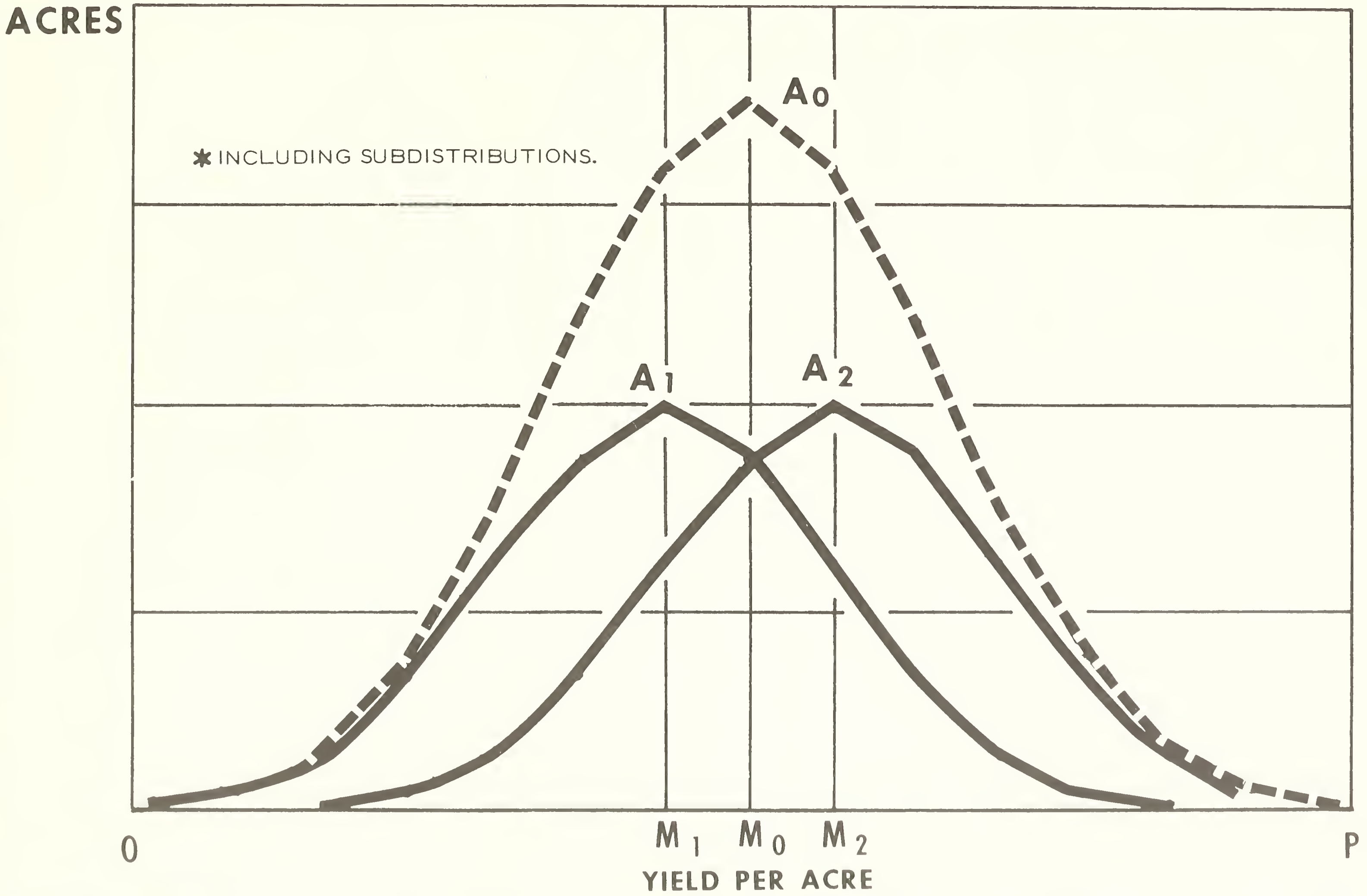
We can depict the first group (maximum total profit) of farms at point M_2 and the least-cost group at point M_1 in figure 1.

Sources of Yield Variability

To summarize, the crop yields of individual farms deviate from the county average for one or more of three reasons:

(1) Purely random causes. These are the unexplained reasons, hence random in the statistical sense. If in fact we could identify and isolate any of the random causes, we would eliminate them by means of stratification. These variations are also known as the sampling error.

FIGURE 1.--THEORETICAL DISTRIBUTION OF CROP YIELDS*



*INCLUDING SUBDISTRIBUTIONS.

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(2) Differences due to crop production hazards. These are nonrandom in the statistical sense because we can identify them with causes such as frost, hail, etc., when they do occur. These differences in yield occur in the short run (a year) when farms within the area do not experience the production hazard equally. The yield differences referred to here are due to abnormal yield losses, those beyond the normal losses as represented by the differential between the potential and the actual yields in figure 1.

(3) Differences among farmers due to production strategies and practices. These differences are nonrandom, and they result in different-level yield subpopulations of farmers within a county or an area; but collectively these subpopulations comprise a county or area average.

Whether these subpopulations are due to differences in production strategies or to differences in managerial competence among farmers, the results are the same. They are subgroups with different yield expectations and different production costs. The yields of each subgroup are subject to the same statistically random causes and to the same effects of natural crop-production hazards.

In view of the differences among farmers and the nonrandom causes affecting yields, it is questionable whether crop yields can be properly considered under our traditional theory of statistical distribution. For example, yield distributions may not be normal in the traditional statistical sense. They may not inevitably tend toward an average. Instead, they may be polarized toward the pure potential yield. Yields may be average only because a normal or average distribution of adverse crop hazards pushes actual yields below their potential.

At this juncture we should note that statistical distribution theory deals with the combined variations both above and below the mean, whereas in crop insurance we are concerned with the lower segment of the yield range.

Impact of Production Technology

Technological improvements such as higher yielding crop varieties, increased rates of fertilization, and (in corn) increased plant populations have greatly increased the crop yield potential. For example, in the central Corn Belt where until recently 100-bushel yields of corn were considered good, some farmers are now applying inputs with the expectation of yields of 150 or even 180 bushels. Thus, yield-increasing technology has tended to move P to the right in figure 1.

But raising the yield potential also increases the crop value that may be lost. New technology has provided additional protection against crop loss from such hazards as disease, insect damage, weed competition, and so on. Nevertheless, epidemics still occur. Moreover, technology can do little to prevent crop loss from freezing temperatures, hail damage, and severe drought. The situation is somewhat analogous to the impact of medical technology on the human lifespan. Though natural life expectancy is increasing, some will still die "before their time" from accidents of various kinds.

While technology has clearly raised both the potential and the average yields, its effect on year-to-year variability is less certain. And the question may differ with respect to the variability of county yields over time versus the yield variability of individual farms around the county average. A cursory inspection of representative corn and wheat counties indicates substantially lower coefficients of variation in county average yields during the last decade than during the preceding decade. This need not imply a similar reduction in the year-to-year variability of the yields of individual farms. The net effect of new technology may be to lessen the overall crop loss but it is no less important for individual farmers to use crop insurance.

Associated with the newer technology has been an increase in production inputs and cost per acre. Thus, the economic sum risked, either in terms of crop investment or of expected gross return, now exceeds the levels 20 or even 10 years ago. But it is not readily apparent that the risk is higher now in terms of probability times the values. Moreover, even though the sum risked may have increased, the economic risk is a relative matter depending upon the farmer's financial situation, particularly his other contractual commitments as, for example, cash rent and amortization payments upon debt.

Relevance to Crop Insurance

In view of the foregoing discussion, several cogent ideas emerge regarding crop insurance.

Conceivably, an all-risk insurance program could be designed to insure the maximum potential yield and protect against all conceivable hazards many of which in moderate degree are now considered normal. But such a program would be quite impractical because the premium rates would have to be prohibitively high.

From the discussion it should be apparent that when insurance coverage (yield guarantee) is made equal to an average of actual yields, the insurance does not protect against all crop loss, of whatever degree, but only against those losses that exceed the average. Similarly, when the insurance coverage (yield guarantee) is made for a level below the average yield, then a portion of even the greater-than-average crop losses are not protected.

If half the farmers in the rating area consistently get below-average yields and the other half get above-average yields, then a single yield guarantee will be relatively attractive to half the farmers and relatively unattractive to the other half. Such a program is inherently destined to reach only half of the potential market.

RELATION OF INSURANCE COVERAGES TO INDEMNITIES AND PREMIUMS ON INDIVIDUAL FARMS

Insurance coverage is the amount of protection bought by the purchaser and the amount of liability assumed by the insurance company. With crop-hail insurance, the coverage, premium rates, and potential indemnities are directly proportional. But with all-risk or multiperil crop insurance, the higher the insurance coverage the greater the probability that an indemnity payment will be due. These inherent differences in the two types of insurance greatly affect the relationships between insurance coverage, premium, and indemnities.

Crop-Hail Insurance

Crop-hail insurance coverage can be purchased in any amount up to the full value of the expected crop. Coverage is a matter of individual choice. On early or preseason contracts, the coverage usually is for an average crop yield, but adjusted for the expectation of the individual farmer. On midseason or late-season purchased contracts, the coverage usually relates to the actual yield prospects for that season's crop. Farmers sometimes delay purchasing insurance until they can see what the crop is like. Tailoring the coverage to the individual's needs or desires presents no problem since the premium rates are proportional to the coverage bought, and indemnities are computed on the percentage of hail (or hail and wind) damage times the amount of coverage in the contract (minus deductible if any), regardless of the potential or actual crop yield. Ususally indemnities are not paid when the damage to the crop is determined to be less than 5 percent, and some contracts have a higher deductible.

For example, if the crop is insured for $60 an acre (60 bushels at $1 per bushel) and the hail damage is certified to be 50 percent, the indemnity payable is $30, even though the half-crop actually harvested may be 20, 40, or any other number of bushels. Indemnities are based upon the amount of insurance purchased and the percentage of crop loss.

Basically, the premium rate is related to the probability that a hail storm will hit the crop, the degree (percentage) of damage, and the dollar value of coverage purchased. Since the premiums of commercial insurance must cover operating expenses and profits, the premium rate need not be directly proportional to the total coverage purchased.

All-Risk or Multiperil Insurance

With all-risk or multiperil insurance, it is impractical to base indemnities on the percentage of damage to the crop because there may be several hazard impacts on the same crop during the growing season. Under such circumstances, the determination of the potential yield and the percentage of damage would be most difficult. A more practical approach in all-risk insurance is to guarantee a basic crop yield, and to base the indemnities on the difference between the guarantee and the actual yield. This is the method used in Federal all-risk crop insurance. Unless the crop is completely destroyed, the loss adjustment must await harvesttime if not the actual harvest.

To illustrate the relationship between all-risk insurance coverages, indemnities, and the required premiums to cover indemnities, we use two examples based on historical yield series for individual farms. One yield series has moderate year-to-year variability in which the yield increases over time. The other series has high year-to-year variability in which the yield does not increase significantly over time. Obviously, the yield variability of concern to crop insurance is that involving the low crop yields--those below average or below the insured level.

Moderate Year-to-Year Variability

In figure 2, we have plotted a 20-year corn yield series in which variability is moderate, but where a low yield will occasionally occur.[11] For example, although the yield averaged 65.5 bushels during the 20 years, there was 1 year (year 9) in which the yield was only 29.3 bushels (fig. 2). In 5 other years the yield was between 40 and 60 bushels, but those years tended to be early in the period. In contrast, the yield exceeded 80 bushels per acre in 5 of the last 7 years of the period. Thus, a least-squares trend line fitted to the data shows that the averaged yield has been increasing at the rate of about 2.0 bushels per year (fig. 2).

In using these data to compute the probability of achieving specified corn yields, we could take either of two approaches:

One approach would be to ignore the apparent trend increase, and use the actual historical yield observations as being representative of the distribution of acre yields to be expected in the future. To aid our analysis, these acre yields are arranged in order of magnitude in the first column of table 16. Succeeding column show the number of bushels by which the yields in the first column fall below specified yield guarantees. For example, the data show a yield of under 50 bushels in 5 of 20 years. The cumulative deficiency in production for the 5 low-yield years would be 40.4 bushels per acre. This figure would be the estimated total of indemnities due on a crop insurance contract that guarantees a 50-bushel yield. If the payoff were at $1 per bushel, the premium revenue needed to recompense for the indemnities alone would be $40.40 or an average of $2.02 a year. Additional premium would be necessary to cover operating expenses and profit.

Similarly, if the yield guarantee were 60 bushels, the indemnities in 20 years would accumulate to 91.4 bushels, $91.40, or an average of $4.57 a year. With a yield guarantee of 64.5 bushels (the 20-year average), the indemnities would accumulate in 20 years to $127.30, an average of $6.37 a year.

Referring again to figure 2, we see that for each of the assumed yield guarantees, all the indemnities would have occurred in the first decade of the 20-year period, none in the last 10 years. In other words, the probability of getting a yield under 50 bushels decreased during the past 20 years.

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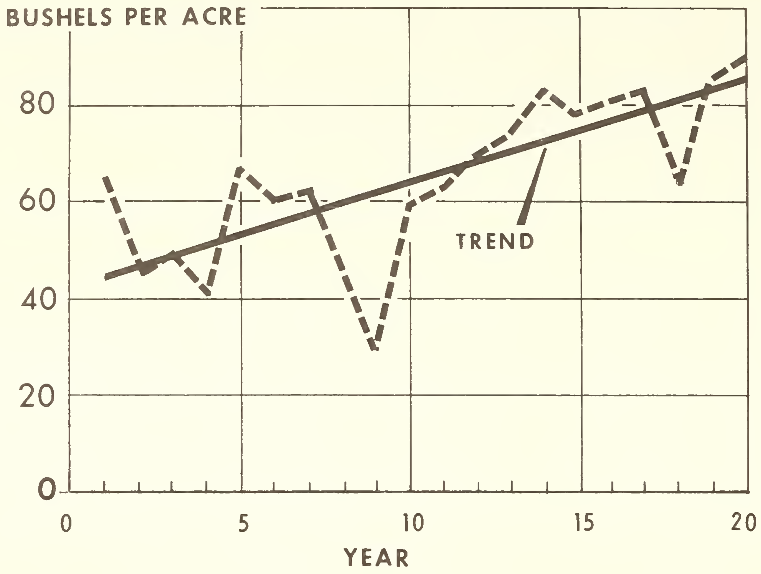
[11] Crop yield variability is lower here than in the Great Plains, but it is higher than, for instance, in the central Corn Belt.

FIGURE 2.--CORN YIELD PER ACRE. 20-YEAR SERIES



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A second approach to computing the probility of achieving a yield is to recognize the apparent upward yield trend and to adjust the 20-year historical distribution of yields to the current projected yield level of 85.5 bushels, as indicated by the trend line (fig. 2). The object is to estimate the probable distribution of yields that might be expected around the figure 85.5. One solution is to measure the deviations of past yields from the trend line, and then to add the plus-differences and subtract the minus-differences from the projected mean of 85.5 bushels. The resulting distribution of probable yields are arrayed in the fifth column of table 16.

As expected, the distribution of yields has a smaller range (about 50 bushels between the highest and lowest) than that (about 60 bushels) of the distribution computed around the historical mean. Using the historical mean confounds the effects of the trend and the true variability.

On the other hand, using the variations from a trend line instead of the historical mean might cause us to underestimate the probable range in the distribution of projected yields. Deviations taken from the lower historical yield level would tend to be smaller (in bushels) than the expected deviations from a higher projected yield level. However, we found that the variance of actual yields around the trend line was nearly twice as large in the first 10 years (when yields were lower) than in the last 10 years (when yields were higher). As anticipated, with the higher projected distribution of yields (21 bushels above the historical average), the estimated indemnities are fewer and much smaller at the same insured yield (table 16).

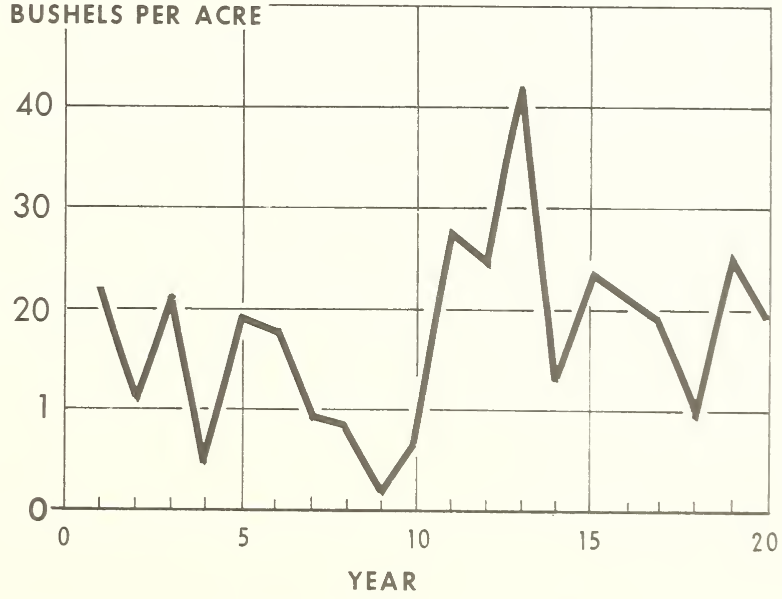
The probability is for the yield to fall below 60 bushels in only 1 year out of 20, fall below 70 bushels in 2 years, fall below 80 bushels in 4 years, and fall below 85.5 (the projected average) in 8 years out of 20. With indemnities paid off at the rate of $1.00 per bushel, the indicated annual premium rates required to cover just the indemnities exclusive of operating expenses or profits, would be $0.34 for a 60-bushel guarantee; $0.85 for the 70-bushel; $2.50 for the 80-bushel; and $4.10 for the 85.5-bushel guarantee. These are, of course, correspondingly smaller than the indicated annual premium rates when the indemnities are estimated on the basis of historical average yields (table 16).

This analysis illustrates the efficacy of basing the crop insurance program on projected instead of historical yields, in an area where the crop yield is significantly increasing.

High Year-to-Year Variability

In table 17 we have a 20-year wheat yield series in which the year-to-year variation is relatively large (fig. 3). The data suggest an upward trend in yield per seeded acre, however, excessive moisture reduced the yield in the 4th year and severe drought seriously reduced crop yields in the 7th through the 10th years. Consequently, the true magnitude of a yield trend, if any, is uncertain. Therefore, in our analysis we use the actual historical yields as the estimated distribution of expected wheat yields. These data are arranged in order of magnitude in the first column of table 17. Succeeding columns show the differences between the actual yields and insured yields of 10, 15, and 17.2 bushels--the last amount being the 20-year average wheat yield for the series.

FIGURE 3.--WHEAT YIELD PER ACRE: 20-YEAR SERIES



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The distribution of actual acre yields suggests that in 6 of 20 years, the expected acre yield will fall below 10 bushels an acre, or that indemnities could be expected in 6 of 20 years. The six indemnities would total 20.1 bushels for an average of 1.0 bushels per year over the 20 years. At $1.50 per bushel, the indemnity payoff would average $1.52 per acre per year over the 20 years; at $2.00 per bushel, it would average $2.02 per year. These are also the indicated annual premium rates required just to cover the projected indemnities. Additional premium would be needed to cover operating expenses and profit of the insuring agency.

For an insured yield of 15 bushels, the data indicate indemnities would be due in 8 of 20 years, totaling 56.2 bushels or averaging 2.81 bushels per year over a 20-year period. At $1.50 per bushel the indemnity payoff (premium required) would average $4.22 per acre. For an insured yield of 17.2 bushels (the projected average), the data again indicate that indemnities would be due in 8 of 20 years, but would total 73.8 bushels and average 3.69 bushels a year. At $1.50 per bushel, the indemnity payoff would average $5.54 per year; at $2.00 per bushel, it would average $7.38.

THE PROBLEM OF ADVERSE INSURANCE RISKS

An additional administrative problem with the all-risk or multiperil crop insurance is that of clearly distinguishing crop losses due to natural causes from those due to the farmer's poor management. The crop may be subject during the growing season to a succession of natural perils whose effect may become confounded with that of any mismanagement. By season's end, it may be difficult to determine exactly the cause of the poor yield. Thus, some claims may be paid in which the farmer's management was partly at fault. This difficulty is not unique to crop insurance; it also can occur in fire and other types of insurance.

The difficulty of identifying crop losses due to the farmer's poor management makes all-risk insurance vulnerable to adverse risks, that is, to clients with an extraordinary chance of having a loss claim. This problem is slight with crop-hail.12/ It is much more likely with all-risk or multiperil insurance. The FCI is especially vulnerable in this regard because of its particular approach to insurance coverage and ratemaking.

FCI maintains a uniform crop yield guarantee and premium rate for all farmers within a designated production area (county or part of a county).13/ Even though environmental conditions may be the same, some farmers within a particular rating area may consistently have crop yields below the area average.

12/ With crop-hail insurance, the event insured against is not the yield per se but the percentage of damage, and the premium is set individually in accordance with the dollar coverage the individual farmer buys. Moreover, the event is not subject to modification by the insured.

13/ Exceptions: individual farm yields are considered in the FCI programs for tobacco, peanuts, sugarcane, and sugarbeets.

Obviously, such farmers represent a higher insurance risk than the average or above average yield farmer. Moreover, farmers who consistently get the lower yields, would find the insurance attractive and, consequently, would be more likely to buy it than farmers who get the average yields. And, of course, the farmers who get well above average yields will consider the insurance coverage and premium rates unfavorable. Thus, in one area a single yield guarantee-premium rate combination may be too high for one segment of the farmers and too low for another. Hence, participation is likely to be greater among the low-yielding farmers, resulting in larger-than-expected crop-loss claims.

If, to compensate for this, the insuring agency reduces yield guarantees, or increases the premium rates in the area, then the insurance offered becomes progressively less attractive.

A solution to the adverse-risk problem in all-risk insurance would be to adjust the insurance coverage for farmers whose yields consistently deviate significantly above or below the yields of the average farmer. The adverse-risk problem is not solved equally well by adjusting the premium rate instead of the yield guarantee. A single, area-wide yield guarantee would still attract the low-yield farmers.

The insurance plan could have one premium rate for all farmers but the yield guarantee would vary for individual farmers in relation to their crop yield history. Farmers would furnish proof of their past yields. Those whose historical yields fell below the county average by a specified amount would have a corresponding lower yield guarantee. Those whose historical yields were above the county average would have a higher-than-average yield guarantee. In short, the yield guarantee could be a uniform percentage of the farmer's historical yield.

The words "consistently" and "significantly" in the preceding discussion may suggest more precision than is intended. The yield history of most farmers would be too short to establish statistically reliable farm averages. However, the individual farmer's yield could be related to the county average year by year. On balance, it might be feasible only to have three categories of yield guarantees. Not only would the low-yield farmers get lower insurance coverage than the average but, conversely, those with consistently above average yields would get higher insurance coverage than the average.

A program that provided for adjustments like those suggested not only would become less attractive to the poor risks but it would become more attractive to the leading farmers in each community who apply more inputs (like fertilizer) per acre and get correspondingly much higher crop yields. An insurance program that would provide them with a higher-than-average yield guarantee, at an appropriate premium, would be more useful and more attractive to them. A program that is attractive to more farmers will have more opportunity to expand.

PROJECTING INDEMNITIES IN ALL-RISK INSURANCE

A company that offers all-risk crop insurance needs to project the probable indemnities it may have to pay its customers. Such data are basic to premium ratemaking, program budgeting, and the management of capital reserves. The need occurs whether the company already has operated some years or is offering the all-risk insurance for the first time. Claims projection is a continuing annual or periodic task.

Indemnities can be projected on several bases used singly or in combination. One basis, of course, is the insuring company's own insurance loss experience because it relates to the class of insureds--high-risk versus low-risk customers--that the company actually insures. Another basis is the loss experience of other insuring companies in the same area. Still another method described is similar to that used at one time by FCIC. The Corporation now depends chiefly upon its own insurance loss experience.

Insured yield guarantees need to be set and indemnities projected even for areas as small as a county so that premium rates can reflect relevant differences in group (county) yield levels. This is particularly necessary in the case of all-risk insurance because yield guarantees and premium rates must be calibrated to basic yield levels that can vary widely. Yield guarantees and premium rates need to reflect such differences, even though as a practical matter it may not be expected that premium rates would ever balance indemnities, county by county.

In the case of all-risk crop insurance, the projections of probable claims must take into account the possible crop losses not just from one cause, such as hail storms, but from all causes. If the insurer undertook to assign probabilities to each cause and add them up--not a matter of simple addition--the task would be formidable. Obviously, an easier way is needed.

The appropriate basis for projecting indemnities is different for all-risk insurance than for crop-hail insurance because of inherent differences in the two.

In the case of crop-hail and other kinds of insurance involving individual risks, the appropriate basis for projecting indemnities is the theory of "extreme values." This theory concerns itself solely with the rare events, those that are several standard deviations away from the contral mass of crop yield observations. This means a count over time of such events to which probabilities can be assigned. To estimate such rare events, the random distribution of aggregate individual crop yields is quite useless.

However, the theory of random distributions is quite appropriate and useful in the case of all-risk crop insurance, because such insurance covers the crop losses from all causes, and involves an insured yield guarantee extending well into the mass of farm yields, approaching the county mean. We can reasonably expect annual individual farm yields to be more or less randomly distributed around the annual group (county) average mean yield. 14/ Then, drawing upon our statistical knowledge of such distributions, we can estimate the probable number of farms or the farm acreage whose yields would fall at various specified levels below the county mean yield. We have in fact a powerful statistical tool for projecting the indemnities for all-risk crop insurance.

"Normal" distributions need not have the same shape. For example, all five of the distributions in figure 4 are normal. They are normal in the sense that each obeys the mathematical function:

$$y = \frac{1}{\sqrt{2\pi}} e^{-x^2/2}$$

Let us now illustrate the use of aggregate yield distributions as the basis for projecting indemnities.

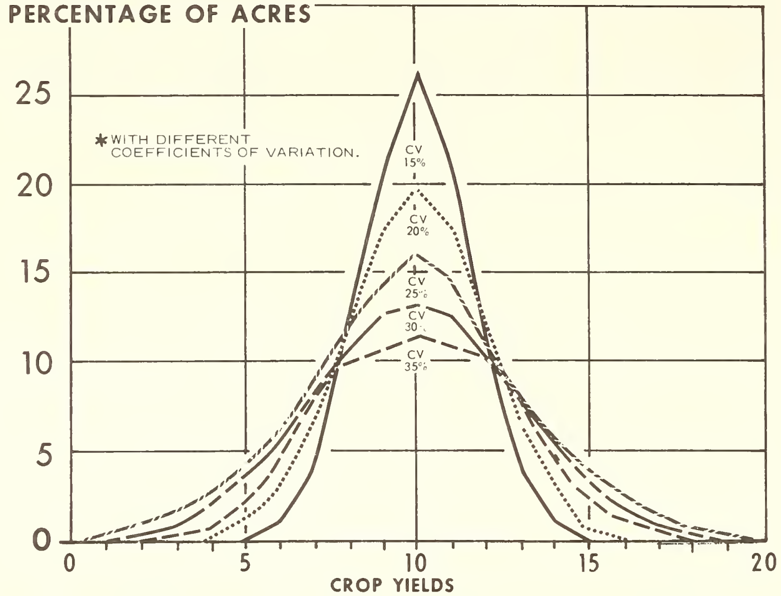
The individual yields of 1,000 farms in a county are assumed to be distributed as in the second column of table 18. The yields range from 4 to 16, and average 10. The symmetry of farm yields above and below the mean is incidental and has no bearing on the outcome of our analysis. With these data we could project the indemnities for any desired insured yield guarantee and price per unit.

For example, suppose the yield guarantee is 8 and the insured rate is $1 per unit. We see that 158 farms have yields under 8, and so we compute total indemnities as follows:

Number of farms	With yields between	Units indemnified: Per farm	Units indemnified: Total	Indemnity, dollars
92	7 and 8	1	92	92
44	6 and 7	2	88	88
17	5 and 6	3	51	51
5	4 and 5	4	20	20
158			251	251

14/ In this discussion, we use the group (county) as the unit of claims projection. Although larger units could be used, the smaller unit has merit for differentiating premium rates between groups (counties), even though it is unnecessary for insurance purposes that premiums equate claims in each and every unit. See a further discussion at the end of this section.

FIGURE 4.--FIVE CROP YIELD DISTRIBUTIONS*



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Similarly, when the yield guarantee is 7, the number of farms to be indemnified is 66 and the number of indemnified units is 44 @ 1 + 17 @ 2, + 5 @ 3, or 93. If less than 1,000 farms were insured, the projected indemnities would be scaled to correspond. We could similarly project the probable indemnities for any other county in which similar aggregate data on the distribution of individual farm yield are available. But such farm yield data are not readily available and are time-consuming and expensive to assemble. Fortunately, such data need not be assembled for every county.

A less laborious alternative rests on the reasonable assumption that distributions of farm yields follow a similar shape or pattern for a crop in a broad area having the same climate and soil type, regardless of the level of the group (county) average yield as, for example, wheat in western Kansas.

By shape or pattern (profile), what we mean in statistical terms is the coefficient of variation (CV). This coefficient is the ratio of the standard deviation of farm yields to the county average yield or, $CV = \frac{\sigma}{m}$. For example, a distribution of farm yields having a mean yield of 10 and a standard deviation of 2.0 would have a coefficient of variation of $\frac{2.0}{10.0}$, or 20 percent. Other distributions having a CV of 20 percent could be said to have the same shape or profile, even though they might have different mean average yields. Five distributions having the same yield but different coefficients of variation are shown in figure 4.

Whereas the coefficient of variation is derived directly from the standard deviation, conversely, the coefficient, when known or assumed, can be used to estimate the standard deviation of farm yields when we know only the county mean yield. In other words,

$$\text{whereas,} \quad CV = \frac{\sigma}{m}$$

$$\text{transposing,} \quad \sigma = (CV)(m).$$

We need the standard deviation to use the "Table of Areas of the Normal Curve" (appendix I) and thus estimate the number of farms or acres likely to have yields at specified levels below the county mean yield.

Let us illustrate the procedure.

Suppose we have a county for which the man yield is 10 and, based on other data, the coefficient of variation is assumed to be 20 percent. The standard deviation is estimated as 20 percent of 10, or 2.0. What percentage of the farm yields are likely to fall between yield 10 and 9, between 9 and 8, and so on?

Because the standard deviation is 2.0 units, the yield 9 is 0.5 standard deviations below the mean yield of 10. Reading from the "Table of Areas of the Normal Curve," we find that when $\frac{x}{\sigma} = 0.5$, the abscissa is 0.1915, indicating that 19.2 percent of the yields probably would fall between yields 9 and 10.

To find the percentage of yields likely to fall between 8 and 9, we subtract the reading for $\frac{x}{\sigma} = 0.5$ from the reading for $\frac{x}{\sigma} = 1.0$.

$$\begin{array}{rr} \text{These readings are} & 0.3413 \\ \text{and} & \underline{-0.1915} \\ & 0.1498 \text{ or } 15.0 \text{ percent} \end{array}$$

Similarly, for other yields:

between	The readings are				percentage
7 and 8	0.4332	-0.3413	=	0.0919	9.2*
6 and 7	0.4773	-0.4332	=	0.0441	4.4
5 and 6	0.4938	-0.4772	=	0.0166	1.7
4 and 5	0.4986	-0.4938	=	0.0048	0.5

* The reader may note the similarity of the percentages in the last column and the column of farm numbers (except for decimal) in table 18.

From the foregoing, it is seen that for projection purposes we need two data: (1) the projected group (county) average yield (or probability of various county average yields) for the year ahead, and (2) the shape of the distribution of individual farm yields below the group (county) average.

The projection of the group (county) average yield for the year ahead (item 1) is facilitated by the fact that historical yield data are available for the major crops, for most counties.15/ To these data we can apply least-squares

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15/ Yields on both a planted and harvested acre basis are estimated by State Crop Reporting Services, in cooperation with the Statistical Reporting Service (USDA).

analysis to establish a trend and to project the probable group (county) mean yield for the year ahead. A least-squares trend is illustrated in figure 2.

We emphasize that a projected group (county) average yield is not an average of past historical yields, but is an estimate of the probable future yield, allowing for any trend. This distinction is important in these days of increasing yields.

Our other problem (item 2), that of characterizing the shape of the distribution of individual farm yields below the projected group (county) average, is more difficult because such data are not readily available for groups (counties) or any other unit.

However, such data could be developed for samples of farms from State crop census records and possibly from Agricultural Stabilization and Conservation (ASC) program records. If the records contain farm average yields already computed, they could be tallied by yield-class intervals in a few sample counties, and possibly repeated for a few years. Coefficients of variation could be computed from the resulting frequency distributions of farm yields.

To illustrate the range of results, figure 4 shows five yield distributions having the same mean yield of 10, but with different coefficients of variation ranging from 15 to 35 percent. In the distribution with a CV of 15 percent, the farm yields are bunched closely about the group yield of 10. In contrast, in the distribution with a CV of 35 percent, the farm yields are well spread out, above and below the mean. A substantial acreage has yields under 7.

These yield distributions probably bracket the relevant range of farm yields for farms having similar soils, climate, and production practices (e.g., irrigated versus dryland farming). At any rate, a distribution with a CV of 40 percent does not differ greatly from the one shown of 35 percent; its use would cause little error. And a distribution with a CV smaller than 15 percent shows almost no acreage with yields under 8 for any yield guarantee under that level.16/

The shape of the distribution would scarcely matter if the insured yield guarantee were also the projected group (county) average yield. Then, whatever the shape, we could expect half the individual farm yields to fall below the group (county) average--provided the distribution was approximately normal. However, it seems more likely that the insured yield will be established well below the projected group (county) average yield.

Thus, two important factors influencing the probable acreage likely to have crop yields below the insured yield guarantee are: (1) the level of the guarantee itself and, (2) the shape of the distribution of individual farm yields. A third factor is the year-to-year fluctuation in the group (county) average yield. The

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16/ The FCIC, when it used a method similar to the one described here, assumed a CV of farm yields equal to 25 percent of the long-term (20 years or more) average county yield. Since current yields were above the long-term average, the method gave a CV somewhat below 25 percent of the current yield.

greater the fluctuation the larger the acreage likely to have crop yields below a specified insured yield--a matter that we explain later.

Let us discuss the effect of the three factors by means of examples. First we shall take up the case where the group (county) average yield does not vary, or varies hardly at all from year to year except for trend. This situation is more typical in the eastern part of the country; it is not typical of the Great Plains.

Case Where Group (County) Crop Yield Does Not Vary From Year to Year

To illustrate the case where the group crop yield does not vary from year to year, we employ example A. The initial data and the steps of the computation are as follows:

Data for Example A:

Group (county) average yield, $m = 10$
Insured yield, $IY = 6$
Coefficient of variation, $CV = 20$ percent

(1) Find standard deviation:

$$\begin{aligned}\sigma &= CV\,(m)\\ &= .20\,(10)\\ &= 2.0\end{aligned}$$

(2) Find difference between mean and insured yields:

$$\begin{aligned}m - IY &= 10 - 6\\ &= 4\end{aligned}$$

(3) Divide the difference by σ.

$$\begin{aligned}\frac{m - IY}{\sigma} &= \frac{4}{2}\\ &= 2.0\end{aligned}$$

(4) From the "Table of Areas of the Normal Curve,"

where $\frac{x}{\sigma} = 2.0$, the value is 0.47725

(5) Subtract this from

$$\begin{array}{r} 0.5000 \\ -0.4772 \\ \hline 0.0228 \end{array} \quad \text{(in hundredths)}$$

(6) Converting the result in (5) from hundredths to percentages, we see that 2.3 percent of the farms or acreage can be expected to have yields below the insured yield of 6.

(7) We could further refine the answer to show the percentage between yield 5 and 6, 4 and 5, and so on. And we could compute the total production units for which an indemnity would be liable, as we did in the example on page 51.

Effect of shape of farm yield distribution

If in Example A we leave other data the same except we raise the coefficient of variation from 20 to 25 percent, which increases the σ from 2.0 to 2.5, the recomputation becomes:

(1) m - IY = 4.0 (as before)

(2) $\frac{m - IY}{\sigma} = \frac{4.0}{2.5}$

$= 1.6$

(3) From the "Table of Areas of the Normal Curve,"

where $\frac{x}{\sigma}$ 1.6, the value is 0.44520

(4) Subtracting that value from

$$\begin{array}{r} 0.5000 \\ -0.4452 \\ \hline 0.0548 \end{array}$$

(5) Converting, the result is 5.5 percent.

Thus, increasing the CV from 20 to 25 percent (where the group mean is 10 and the insured yield is 6) increases the probable acreage having yields below the insured yield from 2.3 to 5.5 percent.

We could, of course, compute the total additional production units that would become liable for an indemnity, as we computed total units in the example on page 51.

Similarly, we can compute the percentage of probable acreage for other farm yield distributions having coefficients of variation ranging from 15 to 40 and summarize our results as follows:

Coefficient of variation ($\frac{\sigma}{m}$) (see fig. 4)	Percentage of acreage with yields below the insured yield
Percent	Percent
15	0.4
20	2.3
25	5.5
30	9.2
35	12.7
40	15.9

Effect of level of insured yield

If in Example A we leave everything the same except we raise the insured yield from 6 to 7, the computation then takes the form:

(1) m - IY = 10 - 7

= 3.0

(2) $\frac{m - IY}{\sigma} = \frac{3.0}{2.0}$

$= 1.5$

(3) In the "Table of Areas of the Normal Curve,"

where $\frac{x}{\sigma}$ 1.5, the value is 0.4332

(4) Subtracting from

$$\begin{array}{r} 0.5000 \\ -0.4332 \\ \hline 0.0668 \end{array}$$

(5) Converting, the result is 6.7 percent.

Thus, raising the insured yield from 6 to 7 (where the group mean is 10) increases from 2.3 to 6.7 percent the probable acreage having yields below the insured yield. We could, as in the example on page 51, compute the total additional production units that would become liable for an indemnity.

Similarly, we can compute the percentage of probable acreage for insured yield guarantees ranging from 4 to 10, and summarize our results as follows:

Insured yield guarantee	Percentage of acreage with yields below the insured yield
	Percent
4	0.1
5	0.6
6	2.3
7	6.7
8	15.9
9	30.8
10	50.0

Combined effect of shape and insured yield

We can extend our analyses to include various combinations of insured yield level and of shape of individual farm yields around the group (county) average yield. Table 19 shows the percentage of the crop acreage likely to have yields below the insured level for each combination of insured yield (column heading) and individual farm yield distribution (the row). The table is standardized for a projected group (county) yield of 10, with insured yields ranging from 4 to 9, and with coefficients of variation (individual yields around the group) ranging from 10 to 50 percent.

Since the table is for a projected group yield of 10, the insured yields of 4, 6, 8, etc. are easily transformed to percentages (40, 60, and 80 percent) of the projected group yield. Hence, the table is easily read for other group yields--a matter of finding the percentage that the insured yield is of the projected (county) yield, and in the appropriate column finding the row opposite the known (or assumed) CV percentage.

Table 19 may be read either by starting with a yield guarantee (column heading) or with the coefficient of variation (left row stub).

If we begin by selecting a yield guarantee, we then look in that column to find the percentage of the acreage likely to have a yield below that guarantee, depending upon the estimated coefficient of variation. For a guarantee of 8, the acreage below the guarantee would be 15.9 percent for a CV of 20, and 25.1 percent for a CV of 30. This reading tells us the effect of different CV's for a given yield guarantee. We note that for yield guarantees below 5 (50 percent of the group yield), the yields on less than 10 percent of the acreage would fall below the guarantee, even though the CV was as high as 35. While coefficients of variation above 35 are unlikely, the table shows CV's up to 50 percent to indicate the progression of relationships.

Or, we can first select the coefficient of variation among the row stubs to see the percentage of acreage likely to have a yield below the guarantee, depending upon what guarantee we select. For a CV of 25, we see that 21.2 percent of the acreage would probably have yields below a guarantee of 8, but only 5.5 percent of the acreage would have yields below a guarantee of 6. This reading tells us the effect of different yield guarantees for a given CV. For a coefficient of variation of 25 percent, we see that less than 12 percent of the acreage would have yields below a guarantee of 7 (70 percent of the group yield).

If we predetermine the maximum percentage of acreage to have probable yields below a guarantee, then we select various combinations of yield guarantees and CV's having percentages within that limit. The limit can be located diagonally from the lower left to the upper right side of the table.

The table can also be used where the projected group (county) yields fluctuate from year to year, by using more than one cell and weighting each accordingly. This will become clearer after the following section has been read.

The discussion thus far has applied to cases where the projected group (county) crop yield does not vary from year to year. We now turn to the case where it does fluctuate.

Cases Where Group (County) Yield Varies Significantly From Year to Year

Where year-to-year variation in group yield is significant as, for example, wheat in the Great Plains and corn in the western Corn Belt, the problem of projecting the acreage whose yield may fall below the insured yield becomes more complex. It is not sufficient merely to base the analysis upon the projected group (county) yield for the year ahead, as we did in Example A--even though that is the most likely yield. Instead, it is necessary to estimate separately the probable acreage for each of several possible group (county) yields, each weighted by its probability of occurrence.

Suppose, for example, the projected group (county) average yield is 10, but our historical yield series indicates that we can expect a below-average yield some years and above-average other years. It is necessary that we estimate for each kind of yield year the probable acreage that will have farm yields below the insured yield of 6.

Our first task is to identify each of the different group (county) yields that might occur in the year ahead based on what we know, including the past experience. One approach is simply to take each group yield for the past 10 years, update them for trend, and assign each a probability of occurrence of 0.10. Another approach is to select typical group yields and assign probabilities to each based on past experience--making certain, of course, that the sum of the probabilities equals 1.0.

Let us illustrate the methods by means of Example B.

Data for Example B:

Basic data are essentially the same as in Example A.

Group (county) average yield, $m = 10$
Insured yield, $IY = 6$
Coefficient of variation, $CV = 20$ percent
(for each group yield)

To assume the sigma is the same percentage of each group yield in the series is more defensible than to assume the same sigma ($\sigma = 2.0$), regardless of group yield; incidentally, assuming the same sigma gives a slightly larger acreage below a specified insured yield.

Suppose further we have identified the possible group yields (rounded for convenience) as shown in the first column of the tabulation below. For convenience, we also show for each group yield the computed σ; the yield minus the insured yield; that remainder divided by the σ; the corresponding area under the normal curve in hundredths; and, the last-named value converted to a percentage.

Tabulation

Annual group yields (y)	(.2 y)	Yield minus insured yield (y - IY)	$\frac{y - IY}{\sigma}$	Area under normal curve	Percentage of acres below insured yield (IY)
16	3.2	10	3.12	0.4991	0.1
14	2.8	8	2.86	.4979	0.2
12	2.4	6	2.50	.4938	0.6
11	2.2	5	2.27	.4884	1.2
10	2.0	4	2.00	.4772	2.3
9	1.8	3	1.67	.4525	4.7
8	1.6	2	1.25	.3944	10.6
6	1.2	0	0	0	50.0
4	0.8	-2	2.50	.4929	99.3

$\sigma = .2\ (m)$
Insured yield, $IY = 6$

Probabilities are thus assigned to each of the group yields in the first column and used as weights against the percentage values in the last column. If the probabilities of occurrence of each yield (first column) are equal, then each has a probability of about 0.111. We can either multiply each percentage figure in the last column by 0.111, or else average the nine figures in the column to get the same sum of 18.8 percent.

However, our historical data may indicate that a yield of 10 has a greater probability of occurrence than other yields, say P=0.30. Suppose the other probabilities are for each of y=9 and y=11, (0.15); for y=8 and y=12, (0.10); y=6 and y=14, (0.07); and y=4 and y=16, (0.03). The composite probable acreage likely to have yields below the insured yield of 6 is found to be 9.2 percent.

It may be more practical to work with only 5 group yields and (on the basis of experience data assign the probabilities: y=16, (.05); y=12, (.20); y=10, (.50); y-8 (.20); and y=4, (.05). With this set, the composite probable acreage with yields below 6 is estimated at 8.3 percent. When using shortcuts of this kind, we must be certain that the shape of the distribution of group yields approximately reflects the pattern of the updated historical yields. The longer method, which uses updated historical group yields, is ordinarily more defensible.

By way of summary, we observe that in crop production situations where the group (county) yield varies significantly from year to year, a larger acreage is likely to have yields below the insured yield than where the group yield does not fluctuate from year to year. The reason is that when the group yield falls, the insured yield cuts much deeper into the group. This, as Example B shows, more than offsets the portion of the group that escapes the insured yield when the group yield rises above average.

The tabulation also shows that even when the group average yield is well above average, say at yield 14 or 16, a small fraction of the acreage would have yields below the insured yield of 6. This suggests that we cannot deal solely with those annual group (county) yields that fall below the projected average.

Concluding Remarks

As a practical matter, an insurer might develop a coefficient of variation that would characterize the distribution of farm yields for a broad area including many counties. Such a coefficient could then be applied to each group (county) mean yield to estimate the standard deviation of farm yields and, in turn, the acreage likely to have yields below a specified (insured) yield. In this way, premium rates could be established county by county, and a projection of claims could be built up for a broader area. Hopefully, the errors in claim projection for individual groups (counties) would be in part compensating.

CAPITAL RESERVE NEEDS IN CROP INSURANCE

The basic principle underlying all insurance is that all insureds pay premiums into a fund from which indemnities can be paid to those insureds who suffer a loss. The premium fund, it is hoped, will keep ahead of the claims against it.

But in crop insurance, crop losses due to natural causes often occur simultaneously to many farmers, in many counties, throughout a region, in the same year. Thus, in some years, indemnity claims may exceed the premium revenue. This is readily apparent from the annual loss ratios reported by FCIC (table 20).

To reduce the likelihood of excessive claims in a single year, a crop insurer may diversify his liability among several crops and geographic areas. Crop-hail companies, for instance, sometimes limit the amount of liability (insurance sold) they will accept in a high-risk area. The liability of FCIC is widely diversified among 25 crops and half the counties in the United States. Another device, often used by the smaller crop-hail companies, is to reinsure with other companies, thus diffusing the burden of liability.

To cope with the possibility that unusually heavy crop-loss claims may exceed the cumulative premium fund, the insurer may need to establish and maintain a capital reserve. For this purpose, the Congress gave FCIC a beginning capital reserve in 1938 and restored the fund in 1948. Commercial insurance companies, except the mutuals, can create a capital reserve by selling corporate stock or bonds. The commercial companies can also augment their capital reserve by charging higher premiums than the anticipated indemnities. Even a slight overcharge accumulates substantially in 10 years. Mutual companies, unable to sell stock, use this approach.

The purpose of this chapter is to explore the likelihood that excessively heavy crop-loss claims may occur in any year or sequence of years. The general approach is to trace the cumulative premiums and cumulative indemnities paid yearly over a period of actual experience, and to note those years when cumulative premium revenue falls behind cumulative indemnities. For our analysis, we have the aggregate data on the actual premiums and the actual indemnities paid annually during the 20-year period 1948-67. Any adjustments the companies made in premium rates to avoid deficits during the period are, of course, included in the data analyzed. The sequence of crop years in the period may or may not be typical of the future. The analysis, based on aggregates, understates the variability to be expected by companies individually. Nevertheless, the results are indicative.

Let us first examine the experience with Federal all-risk crop insurance.

Federal All-Risk Crop Insurance

Our analysis focuses here on the FCI programs for wheat, corn, cotton, and tobacco, all of which operated throughout the 20-year period 1948-67; these programs currently represent about 70 percent of the total FCI business. These crops are also important in commercial crop-hail insurance.

Wheat

The wheat all-risk insurance program is large, involving thousands of contracts, over $200 million coverage, and $15 million in premiums. Grower participation is widely dispersed in the Upper Midwest and the Great Plains. Nearly a fifth of the eligible wheat acreage is insured.

During the 20-year period 1948-67, the FCI wheat program had a loss ratio above 1.00 in 9 years, of which 6 years occurred in the first decade and 3 in the second decade. Moreover, loss ratios above 1.00 occurred in each successive year from 1953 to 1956, years of extensive drought in the Great Plains. The average loss ratio for the 20 years was 0.85 (table 20).

Despite some high loss years, cumulative premium revenue exceeded cumulative indemnities for the first 6 years of the period (table 21). Then cumulative premiums fell behind cumulative indemnities by as much as $4.1 to $8.6 million in each of the next 4 years, 1954-57. A surplus of cumulative premiums reappeared in the 11th year and increased to $22.4 million in the 19th year. During the last 4 years of the period, the cumulative surplus premium held at about double the annual premiums.

The deficit situation in the 7th to 10th years would have been averted by a beginning capital reserve of about $8.6 million. The deficit likewise would have been averted if the program experience of the second decade had preceded that of the first. In that case, the high-loss years would have occurred after a premium surplus had accumulated.

Had premiums throughout the period been scaled down so they were just equal to average indemnities (loss ratio of 1.00), cumulative premiums would have fallen behind indemnities in 11 years (table 21). Moreover, the continuous deficit period would have spanned the 6th to 14th years, and the deficit would have peaked at $18.5 million in the 9th year (1956). That sum was almost twice the average annual premium during the 20 years.

Table 21 also shows the cumulative surplus premium for the 20-year period, had premiums been scaled to 110 percent of average indemnities (about the actual level) and to 120 percent. Premiums at 120 percent would have virtually obviated the need for a reserve. But on the other hand, a premium surplus of $37.5 million--over 3 times the average annual premium--would have accumulated by the 20th year.

This analysis demonstrates the critical nature of premium levels. When the annual premiums exceeded indemnities by about 11 percent (loss ratio 0.90), cumulative premiums fell behind indemnities by $8.6 million in the 9th year, whereas if premiums had been scaled exactly to indemnities (for the 20 years), the 9th-year deficit would have reached $18.5 million. A 10-percent lower premium, though equivalent to indemnities, could make that much difference.

On balance, the FCI record on wheat probably represents the nearest correspondence achievable between premium revenue and indemnities in the long run. Even so, if the FCI wheat account had to stand by itself, a reserve about equal to the annual premiums is indicated.

Corn

The corn all-risk insurance program is also large, involving thousands of contracts, nearly $150 million in coverage, and over $8 million in premiums. Nearly 10 percent of the eligible acreage is insured (table 5).

The FCI program did not succeed as well in matching premiums with indemnities for corn as it did for wheat in the 1948-67 period (table 22). In fact, corn indemnities exceeded premiums by 12 percent over the period. Even so, in 12 of the 20 years, premiums exceeded indemnities. The problem was attributable to six very heavy crop-loss years, namely, the 4th, 9th, 13th, 15th, 17th, and 18th years (table 20).

Premiums exceeded indemnities during most of the first 8 years (1948-55). In fact, in the 8th year there was a cumulative premium surplus equivalent to about 1 year's premium. But in the 9th year (1956), total indemnities were about 3.35 times total premiums, leaving a premium deficit equivalent to about twice the annual premium. That deficit together with large indemnities (loss ratios) in the 13th, 15th, 17th, and 18th years kept cumulative indemnities ahead of cumulative premium revenues for the last 12 years of the period. At the end, the cumulative deficit was roughly equal to 1 year's premium.

Had there been a reserve fund of $4.8 million to meet the deficit of the 9th year, the indemnities from the 10th to 17th years could have been paid from current premium revenue. But the large deficit of $7.2 million in the 18th year would have required another, even larger, diversion from a reserve.

Had the premiums been proportionately higher, such as to equal the indemnities paid over the 20-year period, the number of years in which cumulative revenue fell behind indemnities paid would have been reduced from 13 to 8 years (table 22). Withdrawal from a reserve would still have been necessary to cover indemnities in the 9th year (1956), but the amount would have been reduced to $3.5 million, compared with the actual cumulative deficit of $4.8 million. And another withdrawal of about $2.8 million would have been indicated for the 18th year (1965). See table 22.

Had premiums been proportionately higher for the 20-year period so as to have been 110 percent of total indemnities, there would have been cumulative deficits in only 4 years of the period, the largest being about $2.2 million in the 9th year (1956) (table 22). The 20-year period would have ended with a cumulative premium surplus of about $7 million.

Had premiums averaged 120 percent of indemnities, there would have been a relatively small cumulative deficit in the 9th year, and the end-of-period cumulative premium surplus would have been about $14 million (table 22).

Cotton

The cotton all-risk insurance program is almost as large as the corn program in insurance coverage and premiums. Nearly a sixth of the eligible cotton acreage is insured (table 5).

Premiums exceeded indemnities in 13 of the 20 years (1948-67), but in the other 7 years crop-loss ratios were so large that, on the average, indemnities exceeded premiums by a fourth for the 20-year period (table 20).

Because losses were heavy in the 2nd and 3rd years, cumulative premiums fell $4 million (twice the annual premium) behind indemnities in the 3rd year.

Although from then on the deficit was steadily reduced, the program did not show a cumulative premium surplus until the 13th year (table 23).

The surplus continued through the 19th year, but in the 20th year indemnities soared to 3.85 times the annual premium. So the period ended with a cumulative premium deficit of almost 3 times the annual premium (table 23).

Except for two pairs of very high loss years--one pair at the beginning and the other at the end of the period--premiums were reasonably adjusted to indemnities. In those 4 years, over half of all indemnities of the entire 20-year period were paid out, and the loss ratio averaged 2.91. In the remaining 16 years, the loss ratio averaged 0.72.

Had the premiums been proportionately higher, such as to equal indemnities over the 20-year period, the number of years in which cumulative premium revenue fell behind indemnities paid would have fallen from 10 to 3 years (table 23). Cumulative premiums would have lagged behind indemnities only in the 3rd through 5th years, reaching a deficit of about $2.9 million in the 3rd year of the period.

Had the premiums averaged 110 percent of indemnities over the 20-year period, a cumulative deficit would have occurred in only 2 of 20 years, the largest, $2.3 million, in the 3rd year (table 23). Premium surplus would have soared to $16 million in the 18th year. Thus, had the indemnities of the 2nd and 3rd years appeared later, say after the 7th year, no cumulative deficit would have occurred.

Even if premiums had been 120 percent of indemnities, the cumulative deficit of the 3rd year would not have been eliminated, coming as it did early in the period before a premium surplus could be built up.

Tobacco

The tobacco all-risk insurance program is large, with many thousands of contracts, and provides more insurance coverage than the cotton and corn programs. However, the tobacco insurance program is distinquished by the fact that indemnities exceeded premiums in only 1 year (1953) of the 20-year period, and averaged only 56 percent of the premiums for the period (table 20). In contrast, indemnities for wheat were 85 percent, corn 102 percent, and cotton 111 percent of the premiums, for the 20-year period.

Moreover, there was a cumulative premium surplus throughout the 20-year period, even after the high-loss ratio (1.90) year of 1953. In no year was there a cumulative deficit. Instead of asking, as we did with wheat, corn, and cotton, what the effect would be of scaling premiums up, we ask in the case of tobacco, what would be the effect of scaling them down.

Had the premiums for tobacco been scaled to 120 percent of indemnities (average loss-ratio of 83 percent), cumulative premiums would have fallen behind cumulative indemnities in the 6th year (1953) and continued for 5 years (table 24). The deficit would have peaked at $2.7 million in the 7th year--exceeding the annual premium.

Had the premiums been scaled down to 110 percent of indemnities, a cumulative deficit likewise would have appeared in the 6th year, but would have continued for 7 years (table 24). Again, the deficit would have peaked out in the 7th year, but at $3.2 million.

Had the premiums for tobacco been scaled still lower so as to just equal the indemnities for the period, the cumulative revenue would have fallen behind indemnities in 15 continuous years from the 5th through 19th years. The reason for this is that loss ratios tended to be above average in the early part of the period, including the unusually high loss rate in the 6th year.

Four crop combination

In this analysis, we combine the FCI programs for wheat, corn, cotton, and tobacco for the 20-year period 1948-67. Together, these four programs represent about 70 percent of the coverage, the premiums and the indemnities, of the Federal all-risk crop insurance program (table 5). Together they represent wide geographical dispersion as they hardly overlap each other at all.

The four-crop combination had a loss ratio above 1.00 in 8 of the 20 years--6 of them in the first decade--and averaged 0.90 for the 20-year period (table 20). Thus, premiums exceeded indemnities by 7 percent over the period--about like the wheat program, which in profile the four-crop combination resembles more than any other.

At the beginning of the period, there was a premium surplus over cumulative indemnities for the first 6 years (through 1953). Then followed 4 years of deficits, peaking at -$10.6 million in the 9th year. After the 10th year, a premium surplus reappeared, building up to $33.1 million in the 17th year, and ending the 20th year with a surplus of $23.6 million (table 25).

This analysis indicates that a reserve of $10.6 million--equivalent to about 60 percent of the annual premium at the time--would have carried the four-crop program through the first decade. This was an experimental period for a greatly expanded FCI program. The buildup of premium surplus toward the end of the second decade suggests that a four-crop program could get through a recurrence like the earlier 4 years without drawing from an outside reserve.

Had the premiums for the four-crops been scaled down so as to just equal the indemnities paid out in the 20-year period, the cumulative premium revenue would have fallen behind cumulative indemnities in 10 of the first 12 years. The deficit would have peaked at $20.1 million in the 9th year. Scaling down the premiums in this way greatly accentuates the occurrence of deficits in cumulative premiums. After the 12th year, a premium surplus would have reappeared for the remaining 8 years (table 25).

The table also shows the cumulation of premium revenue for the period when premiums of the four-crop program are scaled upward to 120 percent of the average indemnities. No deficit year occurs and premium surplus accumulates to more than twice the annual premium.

Conclusions

When premiums are scaled to equal the indemnities over a period of years, we find that, at some point, cumulative premiums are likely to fall behind the cumulative indemnities by as much as a full year's premium revenue. Though it gradually diminishes, a deficit may persist a number of years before it eventually disappears. Therefore, a substantial capital reserve may be required, unless crop losses do not become heavy until after a premium surplus has accumulated.

When premiums are scaled to 110 percent of average indemnities, there is less likelihood that cumulative premiums will fall behind cumulative indemnities. It can happen, however, as demonstrated by the analysis for the 20-year period 1948-67.

Scaling premiums to 120 percent of the average indemnities almost removes the likelihood of a premium deficit, and may in fact result in excessive accumulation of premium reserves.

For large programs having broad geographic coverage, a combination of premiums scaled to 110 percent and a moderate-sized capital reserve seems indicated.

In the example analyzed here, a program combining the four crops would have required a smaller capital reserve relative to annual premium than would a program for any one of the four crops alone.

Commercial Crop-Hail Insurance

Aggregate data for individual crops covered by commercial crop-hail insurance is available for the companies that report to the Crop-Hail Insurance Actuarial Association. The total crop-hail business of these companies is roughtly equivalent to the Federal all-risk crop insurance on the four crops--wheat, corn, cotton, and tobacco. For comparison, our analysis covers the same crops and the same 20-year period used for the FCI analysis.

In commercial crop-hail insurance, the premiums average substantially higher than indemnities so as to cover business operating costs and profit as well. For that reason, the loss ratios (indemnities to premiums) are much lower than in FCI in which operating costs are paid by the Government and the program is nonprofit. For example, the loss ratios for the 1948-67 period averaged 0.62 for the commercial crop-hail insurance, compared with 0.93 for the FCI. Nevertheless, we can measure the year-to-year variability over the same period for comparison with FCI.

Wheat

For wheat, the annual loss ratios ranged from 0.36 to 0.86, and averaged 0.59 in the 20-year period 1948-67 (table 26). The coefficient of variation (CV) was 24 percent, indicating that about two-thirds of the loss ratios fell within the range of 24 percent below and 24 percent above the average loss ratio. This coefficient was roughly half the comparable coefficient for the Federal all-risk crop insurance on wheat (tables 20 and 26). Thus, year-to-year variability in loss-ratios was much smaller for the crop-hail insurance.

Table 27 shows the annual premiums, indemnities, and the premium needed to pay indemnities, on the average, for the 20-year period. The cumulative premium surplus, thus defined, runs ahead of indemnities until the 16th year of the period, suggesting that, as a group, companies offering insurance on wheat would not need a capital reserve, though individually the companies might.

Corn

The annual loss ratios for crop-hail insurance on corn ranged from 0.22 to 1.20 and averaged 0.54 for the 20-year period (table 26). The coefficient of variation was 41 percent, compared with 83 percent for the FCI, indicating that year-to-year variability was much smaller for the crop-hail insurance.

In table 28 are found data and computations for corn similar to those in table 27 for wheat. We find that with corn the cumulative premiums needed to pay indemnities, ran ahead of the cumulative indemnities until the 7th year, but fell substantially behind indemnities in the 9th through 11th years of the period. This suggests the need for a capital reserve, built up from surplus premium revenue or from other funds.

Cotton

The annual loss rations for crop-hail insurance on cotton ranged from 0.27 to 0.75 and averaged 0.54 for the 20-year period (table 26). The CV was 24 percent--the same as for wheat, but less than the 82 percent CV for FCI on cotton.

Table 29 shows the data and the computations for crop-hail premiums and indemnities. We find that cumulative premiums needed, on the average, to pay indemnities ran ahead of cumulative indemnities until the 16th year, and then fell behind indemnities by only a moderate amount. No need for capital reserve was indicated, assuming average premium rates and coverage as in the period 1948-67.

Tobacco

The annual loss ratios for crop-hail insurance on tobacco ranged from 0.23 to 1.10 and averaged 0.57 over the 20-year period 1948-67 (table 26). The coefficient of variation (CV), 33 percent, was not as high as that of corn, but was higher than for cotton. The CV's for tobacco and corn were high chiefly because of 1 bad year in each case. Nevertheless, the CV for crop-hail insurance was about half the 64-percent CV for FCI insurance on tobacco.

In table 30 are the annual data on premiums and indemnities for the same 20-year period. We see that the cumulative premiums needed to cover indemnities fell behind cumulative indemnities in the 5th year and remained behind the remainder of the period except for the 12th and 14th years. The largest deficit was $10.8 million in the 9th year, a year when premium revenue was $14.9 million. From the standpoint of heavy claims, crop-hail insurance on tobacco occasionally can have a disastrous year. The likelihood would be even greater for an individual company. Thus a need for capital reserves is indicated.

Four-crop total

When we combine the data and average the crop-hail insurance loss ratios for all four crops, the coefficient of variation falls to 16 percent, compared with CV's of wheat 24, cotton 24, tobacco 33, and corn 41. The 4-crop CV is lower than the CV for all crops combined (table 26). The 4-crop CV was likewise lower than the all-crop CV in the Federal all-risk insurance.

Table 31 shows the annual data on premiums and indemnities for the 20-year period. We find that the cumulative premium surplus needed to pay indemnities ran ahead of cumulative indemnities during the first 8 years of the period and again from the 11th through the 15th years. Cumulative premiums fell $4.1 million behind indemnities in the 16th year when indemnities were $42.2 million, suggesting a capital reserve equivalent to 10 percent of the annual premiums.

Concluding remarks

To summarize, the year-to-year variability in loss ratios of commercial crop-hail insurance was substantially smaller than that of Federal all-risk crop insurance in the 20-year period 1948-67.

In analyzing the cumulative premium surplus over indemnities, we did not include all of the premium revenue because a part of it must be used for operating expenses, hence is not available for paying indemnities. Instead, we scaled all of the annual premiums proportionately so that in total they would just cover total indemnities for the crop(s) for the 20-year period.

On that basis, a capital reserve from which to pay unusual indemnities would not have been indicated for the companies as a group in the case of their crop-hail insurance on wheat and cotton, but would have been indicated for corn and tobacco as well as on the four crops in combination.

Table 16.--Estimated indemnities for specified insured corn yields, based on a 20-year historical yield series and on a projected series

With actual yields				With projected yields 1/				
Array of actual yields	Insured yield of:			Array of projected yields	Insured yield of:			
	50 bushels	60 bushels	64.5 bushels 2/		60 bushels	70 bushels	80 bushels	85.5 bushels 3/
Bushels	Bushel indemnities			Bushels	Bushel indemnities			
89.3				104.1				
84.7				98.8				
83.1				97.1				
82.8				91.5				
81.5				91.3				
77.5				90.8				
73.7				90.1				
69.1				90.				
66.8				89.7				
64.1			0.4	89.5				
63.8			.7	88.7				
63.6			.9	87.1				
62.1			2.4	85.2				0.3
60			4.5	83.6				1.9
59		1.0	5.5	82.1				3.4
49.2	0.8	10.8	15.3	81				4.5
45.7	4.3	14.3	18.8	75.3			4.7	10.2
44.1	5.9	15.9	20.4	71.7			8.3	13.8
41.3	8.7	18.7	23.2	69.8		0.2	10.2	15.7
29.3	20.7	30.7	35.2	53.3	6.7	16.7	26.7	32.2
Total	40.4	91.4	127.3	Total	6.7	16.9	49.9	82.7
Average 64.5	2.02	4.57	6.37	Average 85.5	.34	.85	2.50	4.10
Average value								
at $1.00	$2.02	$4.57	$6.37		$0.34	$0.85	$2.50	$4.10
at $1.20	$2.42	$5.48	$7.64		$0.41	$1.02	$3.00	$4.92

1/ Projected distribution based on deviation of actual yields from a least-squares trend line, applied to the projected yield, 84.5.

2/ 20-year average yield.

3/ Projected yield based on least-squares trend.

Table 17.--Estimated indemnities for specified insured wheat yields, based on 20-year actual yield series

Array of actual yields	Insured yields of:		
	10 bushels	15 bushels	17.2 bushels 1/
Bushels	Bushel indemnities		
41.8			
27.5			
25.1			
24.3			
23.6			
21.9			
21.2			
21.1			
19			
18.8			
18.4			
17.8			
12.9		2.1	4.3
11		4	6.2
9.3	0.7	5.7	7.9
9.1	.9	5.9	8.1
8.1	1.9	6.9	9.1
7.3	2.7	7.7	9.9
4.6	5.4	10.4	12.6
1.5	8.5	13.5	15.7
Total: 344.3	20.1	56.2	73.8
Average: 17.2	1.01	2.81	3.69
Average value			
at $1.50 per bushel	$1.52	$4.22	$5.54
at $2.00 per bushel	$2.02	$5.62	$7.38

1/ 20-year county average yield.

Table 18.--An example distribution of individual farm yields in a county

Individual farm yield (y)	Number of farms (n)	Total production (Y x N)	Deviations below mean (d)	(d^2)	d^2n
(1)	(2)	(3)	(4)	(5)	(6)
15 - 16	5	78			
14 - 15	17	246			
13 - 14	44	594			
12 - 13	92	1,150			
11 - 12	150	1,725			
10 - 11	192	2,016	0	0	
9 - 10	192	1,824	.5	.25	48.00
8 - 9	150	1,275	1.5	2.25	337.50
7 - 8	92	690	2.5	6.25	575.00
6 - 7	44	286	3.5	12.25	539.00
5 - 6	17	94	4.5	20.25	344.25
4 - 5	5	22	5.5	30.25	156.25
	1,000	10,000			2,000.00

Mathematic notation:

$$M = 10,000 \div 1,000 = 10$$

$$\sigma = \sqrt{\frac{(d^2n)}{n}} = \sqrt{\frac{2,000}{500}}\sqrt{\ = 4}$$

$$\sigma = 2.0$$

$$CV = \frac{\sigma}{m}, \quad = \frac{2.0}{10.0}$$

$$CV = .20$$

Table 19.--Proportion of farm yields likely to fall below specified insured yields, when the group yield is 10 1/

Yield variability among farms (coefficient of variation below the mean)	Insured yield guarantee 2/					
	4	5	6	7	8	9
Percent	Percentage of acres below the guarantee					
10.0	0	0	0	0.1	2.3	15.9
15.0	*	*	0.4	2.3	9.2	25.5
20.0	0.1	0.6	2.3	6.7	15.9	30.8
25.0	0.6	2.3	5.5	11.5	21.2	34.5
30.0	2.3	4.8	9.2	15.9	25.1	37.1
35.0	4.4	7.6	12.7	19.5	28.4	39.0
40.0	6.7	10.6	15.9	22.7	30.8	40.0
45.0	9.2	13.4	18.7	25.1	33.0	41.3
50.0	11.5	15.9	21.2	27.4	34.5	42.1

1/ Based on area under the normal curve.

2/ For an insured yield of 10, half of the farm yields would be below the insured, regardless of the yield variability among farms.

Table 20.--Indemnities paid per dollar of premium income (loss ratio), selected crops, FCI, 1948-67 1/

Year	Wheat	Corn	Cotton	Tobacco	Four crops 2/	All crops
	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.
1948	0.58	0.17	0.43	0.43	0.54	0.53
1949	1.43	.16	1.97	.66	1.39	1.31
1950	.52	1.26	2.81	.61	.92	.91
1951	1.06	2.38	.82	.49	1.05	1.12
1952	.85	.25	.44	.79	.75	.97
1953	1.25	.17	1.05	1.90	1.20	1.15
1954	1.42	.56	.56	.89	1.22	1.24
1955	1.26	1.47	.84	.40	1.12	1.14
1956	1.09	3.35	.67	.28	1.30	1.26
1957	.60	.46	.54	.34	.54	.69
1958	.16	.56	.25	.19	.23	.26
1959	.68	.87	.45	.38	.67	.77
1960	.23	1.45	.52	.35	.57	.58
1961	1.09	.23	1.38	.29	.84	.89
1962	.38	1.52	1.24	.79	.83	1.10
1963	.95	.41	.70	.62	.72	.77
1964	.57	1.67	.46	.31	.81	.90
1965	1.24	2.04	.84	.53	1.32	1.13
1966	.54	.45	2.29	.59	.70	.69
1967	1.14	.94	3.85	.38	1.30	1.27
Average 3/	.85	1.02	1.11	.56	.90	.93
Standard deviation 4/	.38	.85	.91	.36	.31	.40
C.V. 5/	45	83	82	64	34	43

1/ Annual ratios from FCIC Annual Report, 1968.

2/ Computed from aggregate unrounded data for the four crops.

3/ Simple average of annual ratios.

4/ Standard deviation: square root of the average of the squared deviations from the mean.

5/ Standard deviation divided by the mean, multiplied by 100.

Table 21.--Wheat: FCI premiums, indemnities, and cumulative premium surplus (or deficit), 1948-67 1/

(Dash indicates less than $50,000)

Year	Annual premiums	Annual indemnities	Cumulative premium surplus 2/	Cumulative premium surplus with premiums scaled to percentages of total indemnities 3/		
				100 percent	110 percent	120 percent
	Mil. dol.	Mil. dol.	Mil. dol.	Mil. dol.	Mil. dol.	Mil. dol.
1948	8.6	5.0	3.6	2.7	3.5	4.3
1949	7.8	11.2	.2	-1.4	.1	1.6
1950	8.3	4.3	4.2	1.8	4.0	6.2
1951	11.1	11.7	3.5	-	3.3	6.5
1952	12.4	10.6	5.4	.7	5.0	9.4
1953	16.1	20.0	1.4	-4.8	.9	6.7
1954	13.0	18.5	-4.1	-11.6	-4.7	2.3
1955	13.2	16.7	-7.5	-16.4	-8.2	-.1
1956	11.3	12.3	-8.6	-18.5	-9.3	-.2
1957	8.1	4.9	-5.3	-16.1	-6.2	3.8
1958	9.4	1.5	2.6	-9.1	1.7	12.5
1959	8.6	5.9	5.4	-7.1	4.4	15.9
1960	7.9	1.8	11.5	-1.8	10.4	22.7
1961	8.4	9.2	10.7	-3.4	9.6	22.6
1962	7.3	2.8	15.2	.4	14.1	27.8
1963	8.6	8.2	15.7	-	14.5	28.9
1964	10.3	5.9	20.1	3.4	18.8	34.2
1965	11.6	14.3	17.3	-.5	15.9	32.4
1966	11.0	5.9	22.4	3.5	21.0	38.4
1967	14.6	16.7	20.3	0	18.7	37.5
Total	207.6	187.3				

1/ Based on unrounded data from FCIC Annual Report, 1968.

2/ Cumulative premiums minus cumulative indemnities equals cumulative premium surplus or deficit. Deficits are shown with a minus sign.

3/ All premiums in first column were scaled so their total was a specified percentage of total indemnities for the 20 years, then cumulative premium surplus as recomputed.

Table 22.--Corn: FCI premiums, indemnities, and cumulative premium surplus (or deficit), 1948-67 1/

(Dash indicates less than $50,000)

Year	Annual premiums	Annual indemnities	Cumulative premium surplus 2/	Cumulative premium surplus with premiums scaled to percentages of total indemnities 3/		
				100 percent	110 percent	120 percent
	Mil. dol.	Mil. dol.	Mil. dol.	Mil. dol.	Mil. dol.	Mil. dol.
1948	0.4	0.1	0.4	0.4	0.5	0.5
1949	.6	.1	.9	1.0	1.1	1.2
1950	.7	.9	.7	.9	1.1	1.3
1951	1.1	2.6	-.8	-.5	-.2	.2
1952	1.4	.3	.2	.7	1.2	1.6
1953	1.7	.3	1.6	2.3	2.9	3.6
1954	1.4	.8	2.2	3.1	3.9	4.7
1955	1.4	2.0	1.5	2.6	3.5	4.5
1956	2.7	9.1	-4.8	-3.5	-2.2	-.9
1957	2.2	1.0	-3.6	-2.0	-.5	1.0
1958	2.1	1.2	-2.7	-.8	.9	2.7
1959	3.4	3.0	-2.3	-	2.2	4.3
1960	3.6	5.2	-3.9	-1.2	1.4	3.9
1961	2.8	.6	-1.8	1.3	4.1	7.0
1962	3.6	5.5	-3.7	-.1	3.1	6.4
1963	5.1	2.1	-.6	3.5	7.3	11.2
1964	6.3	10.5	-4.8	.1	4.6	9.1
1965	7.0	14.2	-12.1	-6.3	-1.0	4.3
1966	7.3	3.3	-8.1	-1.5	4.7	10.8
1967	8.3	7.8	-7.6	0	7.1	14.1
Total	62.9	70.5				

1/ Based on unrounded data from FCIC Annual Report, 1968.

2/ Cumulative premiums minus cumulative indemnities equals cumulative premium surplus or deficit. Deficits are shown with a minus sign.

3/ All premiums in first column were scaled so their total was a specified percentage of total indemnities for the 20 years, then cumulative premium surplus as recomputed.

Table 23.--Cotton: FCI premiums, indemnities, and cumulative premium surplus (or deficit), 1948-67 1/

(Dash indicates less than $50,000)

Year	Annual premiums	Annual indemnities	Cumulative premium surplus 2/	Cumulative premium surplus with premiums scaled to percentages of total indemnities 3/		
				100 percent	110 percent	120 percent
	Mil. dol.	Mil. dol.	Mil. dol.	Mil. dol.	Mil. dol.	Mil. dol.
1948	1.4	0.6	0.8	1.1	1.3	1.5
1949	1.6	3.1	-.7	-	.4	.7
1950	1.8	5.1	-4.0	-2.9	-2.3	1.7
1951	2.7	2.2	-3.6	-1.8	-.9	.1
1952	2.1	.9	-2.4	-.1	1.0	2.2
1953	2.4	2.5	-2.5	.3	1.8	3.3
1954	1.5	.8	-1.9	1.3	3.0	4.6
1955	1.2	1.1	-1.7	1.8	3.6	5.4
1956	1.7	1.1	-1.1	2.8	4.8	6.8
1957	1.1	.6	-.6	3.5	5.7	7.9
1958	.8	.2	-	4.3	6.5	8.8
1959	1.3	.6	-.7	5.3	7.7	10.1
1960	1.2	.6	1.3	6.2	8.7	11.3
1961	1.3	1.8	.8	6.0	8.7	11.4
1962	2.2	2.8	.2	6.0	9.0	12.0
1963	3.5	2.5	1.3	7.9	11.3	14.7
1964	3.6	1.7	3.2	10.7	14.5	18.4
1965	2.8	2.4	3.7	11.8	16.0	20.2
1966	2.5	5.7	.5	9.2	13.7	18.2
1967	3.5	13.5	-9.5	0	5.0	9.9
Total	40.2	49.7				

1/ Based on unrounded data from FCIC Annual Report, 1968.

2/ Cumulative premiums minus cumulative indemnities equals cumulative premium surplus or deficit. Deficits are shown with a minus sign.

3/ All premiums in first column were scaled so their total was a specified percentage of total indemnities for the 20 years, then cumulative premium surplus as recomputed.

Table 24.--Tobacco: FCI premiums, indemnities, and cumulative premium surplus (or deficit), 1948-67 1/

(Dash indicates less than $50,000)

Year	Annual premiums	Annual indemnities	Cumulative premium surplus 2/	Cumulative premium surplus with premiums scaled to percentages of total indemnities 3/		
				100 percent	110 percent	120 percent
	Mil. dol.	Mil. dol.	Mil. dol.	Mil. dol.	Mil. dol.	Mil. dol.
1948	0.7	0.3	0.4	0.1	0.1	0.2
1949	.7	.5	.6	-	.1	.2
1950	1.5	.9	1.2	-.1	.1	.2
1951	1.6	.8	2.0	-	.3	.5
1952	1.5	1.2	2.3	-.3	-	.4
1953	2.0	3.9	.5	-3.0	-2.6	-2.1
1954	2.4	2.1	.8	-3.8	-3.2	-2.7
1955	2.7	1.1	2.4	-3.4	-2.6	-1.9
1956	2.2	.6	4.0	-2.8	-1.9	-1.0
1957	1.6	.6	5.0	-2.4	-1.5	-.5
1958	1.7	.3	6.4	-1.8	-.8	.3
1959	1.7	.6	7.4	-1.5	-.4	.7
1960	2.0	.7	8.7	-1.1	.1	1.4
1961	2.1	.6	10.2	-.5	.8	2.2
1962	3.3	2.6	10.9	-1.3	.2	1.8
1963	3.7	2.3	12.3	-1.5	.2	2.0
1964	3.4	1.1	14.6	-.7	1.2	3.2
1965	3.4	1.8	16.2	-.6	1.5	3.6
1966	4.0	2.4	17.8	-.8	1.6	4.0
1967	4.2	1.6	20.4	0	2.6	5.2
Total	46.3	25.9				

1/ Based on unrounded data from FCIC Annual Report, 1968.

2/ Cumulative premiums minus cumulative indemnities equals cumulative premium surplus or deficit. Deficits are shown with a minus sign.

3/ All premiums in first column were scaled so their total was a specified percentage of total indemnities for the 20 years, then cumulative premium surplus as recomputed.

Table 25.--Four crops combined: FCI premiums, indemnities, and cumulative premium surplus (or deficit), 1948-67 1/

(Dash indicates less than $50,000)

Year	Annual premiums	Annual indemnities	Cumulative premium surplus 2/	Cumulative premium surplus with premiums scaled to percentages of total indemnities 3/		
				100 percent	110 percent	120 percent
	Mil. dol.	Mil. dol.	Mil. dol.	Mil. dol.	Mil. dol.	Mil. dol.
1948	11.1	6.0	5.1	4.4	5.4	6.4
1949	10.7	14.9	.9	-.5	1.5	3.6
1950	12.3	11.2	2.0	-.3	2.9	6.1
1951	16.4	17.3	1.1	-2.2	2.5	7.2
1952	17.4	13.0	5.5	1.0	7.3	13.7
1953	22.1	26.6	1.0	-5.0	3.4	11.9
1954	18.2	22.2	-3.0	-10.0	-	10.1
1955	18.5	20.8	-5.3	-13.7	-1.8	10.0
1956	17.9	23.2	-10.6	-20.1	-6.6	6.9
1957	13.1	7.0	-4.5	-15.0	-.2	14.5
1958	13.9	3.2	6.2	-5.1	10.9	26.9
1959	15.0	10.1	11.2	-1.2	16.3	33.7
1960	14.7	8.3	17.5	4.2	23.0	41.9
1961	14.6	12.2	19.9	5.7	25.8	46.0
1962	16.5	13.6	22.7	7.4	29.1	50.9
1963	20.9	15.0	28.7	11.9	35.6	59.2
1964	23.6	19.1	33.1	14.8	40.7	66.5
1965	24.8	32.8	25.2	5.2	33.4	61.6
1966	24.7	17.2	32.6	11.1	41.5	72.0
1967	30.5	39.6	23.6	0	33.3	66.7
Total	357.0	333.4				

1/ The four crops are wheat, corn, cotton, and tobacco. Based on unrounded data from FCIC Annual Report, 1968.

2/ Cumulative premiums minus cumulative indemnities equals cumulative premium surplus or deficit. Deficits are shown with a minus sign.

3/ All premiums in first column were scaled so their total was a specified percentage of total indemnities for the 20 years, then cumulative premium surplus as recomputed.

Table 26.--Indemnities paid per dollar of premium income (loss ratio), selected crops, crop-hail insurance companies, 1948-67 1/

Year	Wheat	Corn	Cotton	Tobacco	Four crops 2/	All crops
	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.
1948	0.45	0.40	0.54	0.59	0.47	0.53
1949	.64	.22	.38	.38	.50	.49
1950	.37	.31	.56	.50	.42	.42
1951	.62	.60	.52	.73	.64	.67
1952	.36	.49	.27	.84	.49	.53
1953	.51	.80	.31	.54	.53	.72
1954	.54	.78	.39	1.10	.74	.75
1955	.71	.32	.65	.60	.60	.58
1956	.57	1.20	.60	.65	.70	.94
1957	.80	.41	.75	.32	.60	.61
1958	.66	.47	.49	.23	.52	.53
1959	.43	.35	.66	.32	.42	.46
1960	.52	.57	.66	.46	.54	.58
1961	.58	.63	.52	.69	.61	.69
1962	.86	.58	.70	.61	.72	.75
1963	.85	.44	.65	.77	.72	.65
1964	.59	.68	.50	.46	.57	.64
1965	.57	.58	.52	.56	.57	.63
1966	.65	.26	.49	.50	.50	.49
1967	.59	.71	.68	.52	.61	.71
Average 3/	.59	.54	.54	.57	.57	.62
Standard deviation 4/	.14	.22	.13	.19	.09	.12
C.V. 5/	24	41	24	33	16	19

1/ Includes data for the insurance companies that report to the Crop-Hail Insurance Actuarial Association.

2/ Computed from aggregate unrounded data for the four crops.

3/ Simple average of annual ratios.

4/ Standard deviation: square root of the average of the squared deviations from the mean.

5/ Standard deviation divided by the mean, multiplied by 100.

Table 27.--Crop-hail insurance: Premiums, indemnities and premium surplus, wheat, 1948-67 1/

Year	Wheat			
	Premium		Indemnities	Cumulative premium surplus 3/
	Income	Needed to pay indemnities 2/		
	Mil. dol.	Mil. dol.	Mil. dol.	Mil. dol.
1948	13.9	8.4	6.2	2.2
1949	16.2	9.8	10.4	1.6
1950	9.1	5.5	3.4	3.7
1951	11.3	6.9	7.0	3.6
1952	18.9	11.5	6.8	8.3
1953	15.5	9.4	7.9	9.8
1954	15.4	9.4	8.3	10.9
1955	14.3	8.7	10.2	9.4
1956	14.5	8.8	8.3	9.9
1957	20.5	12.4	16.4	5.9
1958	30.0	18.2	19.9	4.2
1959	24.3	14.7	10.5	8.4
1960	26.5	16.1	13.8	10.7
1961	24.2	14.7	14.1	11.3
1962	24.7	15.0	21.2	5.1
1963	23.8	14.5	20.2	-.6
1964	23.7	14.4	14.1	-.3
1965	23.8	14.5	13.7	.5
1966	19.9	12.1	13.0	-.4
1967	25.1	15.2	14.8	0
Total	395.6	240.2	240.2	0

1/ Includes data for the insurance companies that report to the Crop-Hail Insurance Actuarial Association.

2/ Computed as 60.72 percent of the premium income, the percentage necessary to pay the actual indemnities over the 20-year period.

3/ Cumulative difference between premium needed (second column) and the indemnities paid (third column).

Table 28.--Crop-hail insurance: Premiums, indemnities and premium surplus, corn, 1948-67 1/

Year	Corn			
	Premium		Indemnities	Cumulative premium surplus 3/
	Income	Needed to pay indemnities 2/		
	Mil. dol.	Mil. dol.	Mil. dol.	Mil. dol.
1948	3.8	2.1	1.5	0.6
1949	3.5	1.9	.8	1.7
1950	2.8	1.5	.9	2.3
1951	3.2	1.8	1.9	2.2
1952	3.7	2.0	1.8	2.4
1953	5.0	2.7	4.0	1.1
1954	5.7	3.1	4.4	-.2
1955	6.5	3.5	2.1	1.2
1956	6.5	3.5	7.8	-3.1
1957	7.4	4.0	3.1	-2.2
1958	7.6	4.1	3.6	-1.7
1959	12.4	6.8	4.5	.6
1960	11.9	6.5	6.7	.4
1961	10.0	5.5	6.3	-.4
1962	10.2	5.6	5.9	-.7
1963	11.7	6.4	5.1	.6
1964	11.2	6.1	7.6	-.9
1965	11.9	6.5	6.9	-1.3
1966	13.2	7.2	3.4	2.5
1967	15.9	8.7	11.2	0
Total	164.1	89.5	89.5	0

1/ Includes data for the insurance companies that report to the Crop-Hail Insurance Actuarial Association.

2/ Computed as 54.54 percent of the premium income, the percentage necessary to pay the actual indemnities over the 20-year period.

3/ Cumulative difference between premium needed (second column) and the indemnities paid (third column).

Table 29.--Crop-hail insurance: Premiums, indemnities and premium surplus, cotton, 1948-67 1/

Year	Cotton			
	Premium		Indemnities	Cumulative premium surplus 3/
	Income	Needed to pay indemnities 2/		
	Mil. dol.	Mil. dol.	Mil. dol.	Mil. dol.
1948	1.3	0.7	0.7	0
1949	2.1	1.2	.8	.4
1950	1.3	.7	.7	0
1951	4.7	2.7	2.5	.6
1952	5.5	3.1	1.5	2.2
1953	5.2	2.9	1.6	3.5
1954	4.5	2.5	1.8	4.2
1955	5.3	3.0	3.4	3.8
1956	5.6	3.2	3.4	3.6
1957	7.2	4.1	5.4	2.3
1958	7.4	4.2	3.6	2.9
1959	8.3	4.7	5.5	2.1
1960	8.6	4.9	5.7	1.3
1961	8.2	4.6	4.3	1.6
1962	9.8	5.5	6.9	.2
1963	9.0	5.1	5.9	-.6
1964	6.6	3.7	3.3	-.2
1965	7.7	4.3	4.0	.1
1966	3.7	2.1	1.8	.4
1967	3.7	2.1	2.5	0
Total	115.7	65.3	65.3	0

1/ Includes data for the insurance companies that report to the Crop-Hail Insurance Actuarial Association.

2/ Computed as 56.44 percent of the premium income, the percentage necessary to pay the actual indemnities over the 20-year period.

3/ Cumulative difference between premium needed (second column) and the indemnities paid (third column).

Table 30.--Crop-hail insurance: Premiums, indemnities and premium surplus, tobacco, 1948-67 1/

Year	Tobacco			
	Premium		Indemnities	Cumulative premium surplus 3/
	Income	Needed to pay indemnities 2/		
	Mil. dol.	Mil. dol.	Mil. dol.	Mil. dol.
1948	4.9	2.8	2.9	-0.1
1949	6.1	3.5	2.0	1.4
1950	6.1	3.5	3.1	1.8
1951	9.3	5.3	6.8	.3
1952	11.0	6.2	9.2	-2.7
1953	11.8	6.7	6.3	-2.3
1954	12.5	7.1	13.7	-8.9
1955	15.7	8.9	9.5	-9.5
1956	14.9	8.4	9.7	-10.8
1957	13.2	7.5	4.2	-7.5
1958	13.4	7.6	3.1	-3.0
1959	14.1	8.0	4.4	.6
1960	13.9	7.9	6.4	2.1
1961	15.5	8.8	10.7	.2
1962	13.9	7.9	8.4	-.3
1963	14.3	8.1	11.0	-3.2
1964	14.4	8.2	6.6	-1.6
1965	12.8	7.3	7.2	-1.5
1966	13.9	7.9	7.0	-.6
1967	14.2	8.0	7.4	0
Total	245.9	139.6	139.6	0

1/ Includes data for the insurance companies that report to the Crop-Hail Insurance Actuarial Association.

2/ Computed as 56.77 percent of the premium income, the percentage necessary to pay the actual indemnities over the 20-year period.

3/ Cumulative difference between premium needed (second column) and the indemnities paid (third column).

Table 31.--Crop-hail insurance: Premiums, indemnities and premium surplus, four crops, 1948-67 1/

Year	Four crops 2/			
	Premium		Indemnities	Cumulative premium surplus 4/
	Income	Needed to pay indemnities 3/		
	Mil. dol.	Mil. dol.	Mil. dol.	Mil. dol.
1948	23.9	13.9	11.3	2.6
1949	27.9	16.2	14.0	4.8
1950	19.3	11.2	8.1	7.9
1951	28.5	16.5	18.2	6.2
1952	39.1	22.7	19.3	9.6
1953	37.5	21.8	19.8	11.6
1954	38.1	22.1	28.2	5.5
1955	41.8	24.3	25.2	4.6
1956	41.5	24.1	29.2	-.5
1957	48.3	28.0	29.1	-1.6
1958	58.4	33.9	30.2	2.1
1959	59.1	34.3	24.9	11.5
1960	60.9	35.3	32.6	14.2
1961	57.9	33.6	35.4	12.4
1962	58.6	34.0	42.4	4.0
1963	58.8	34.1	42.2	-4.1
1964	55.9	32.4	31.6	-3.3
1965	56.2	32.6	31.8	-2.5
1966	50.7	29.4	25.2	1.7
1967	58.9	34.2	35.9	0
Total	921.3	534.6	534.6	0

1/ Includes data for the insurance companies that report to the Crop-Hail Insurance Actuarial Association.

2/ Total of wheat, corn, cotton, and tobacco.

3/ Computed as 58.03 percent of the premium income, the percentage necessary to pay the actual indemnities over the 20-year period.

4/ Cumulative difference between premium needed (second column) and the indemnities paid (third column).

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APPENDIX I

Table of Areas of the Normal Curve

$\frac{x}{\sigma}$	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.0000	.0040	.0080	.0120	.0159	.0199	.0239	.0279	.0319	.0359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0753
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2257	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2518	.2549
0.7	.2580	.2612	.2642	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2995	.3023	.3051	.3078	.3106	.3233
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3718	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4083	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4430	.4441
1.6	.4452	.4463	.4474	.4485	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4758	.4762	.4767
2.0	.4773	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4865	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4980	.4980	.4981
2.9	.4981	.4982	.4983	.4984	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.49865	.4987	.4987	.4988	.4988	.4988	.4989	.4989	.4989	.4990
3.1	.49903	.4991	.4991	.4991	.4992	.4992	.4992	.4992	.4993	.4993
3.2	.49931									
3.3	.49952									
3.4	.49966									
3.5	.49977									
3.6	.49984									
3.7	.49989									
3.8	.49993									
3.9	.49995									
4.0	.49997									

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